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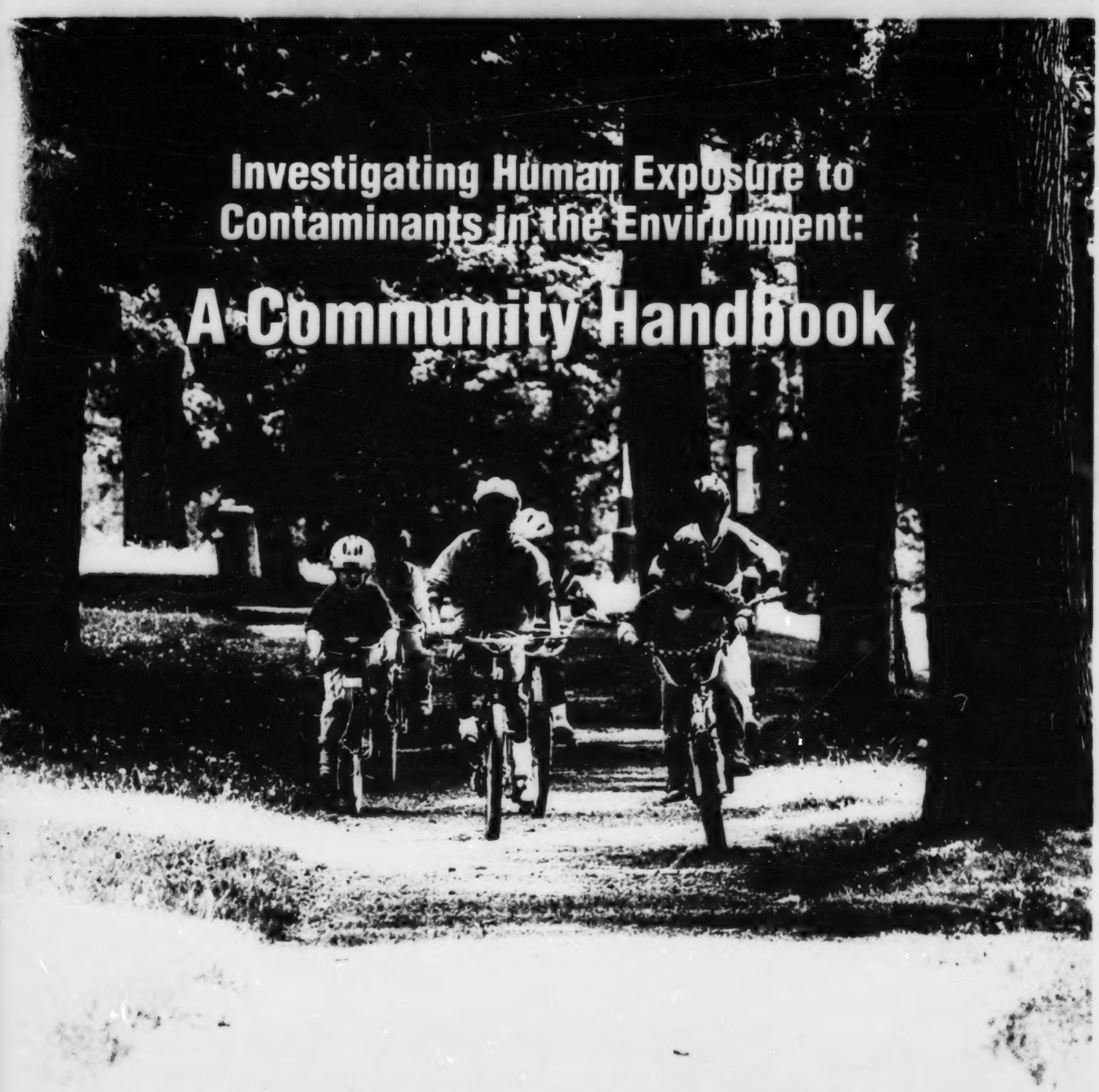
Investigating Human Exposure to Contaminants in the Environment:

A Community Handbook



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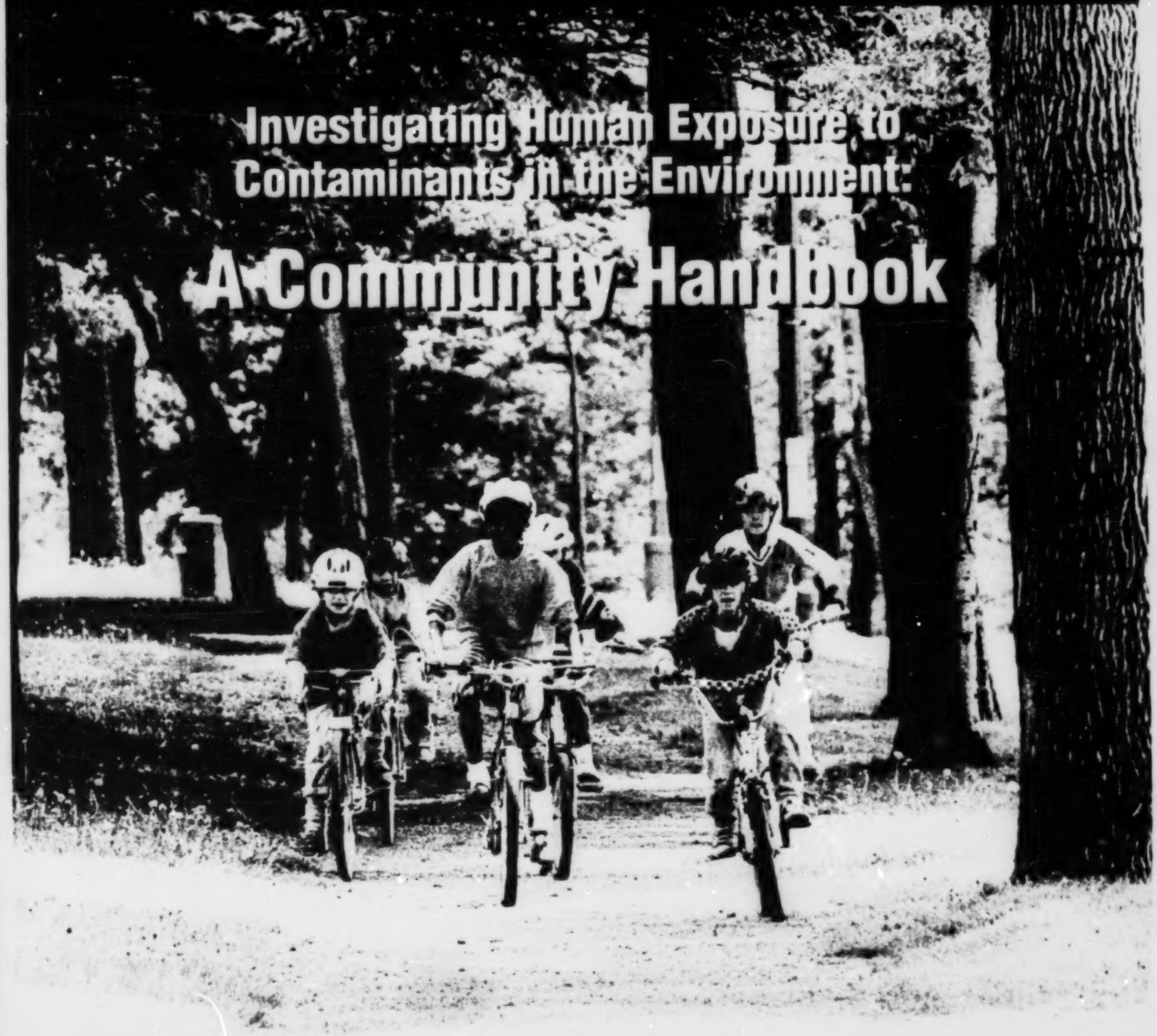

Investigating Human Exposure to Contaminants in the Environment:

A Community Handbook

Our mission is to help the people of Canada
maintain and improve their health.

Health Canada

Published by authority of the Minister of National Health and Welfare

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Cat. No. H49-96/2-1995E
ISBN-0-662-23544-4

Également offert en français sous le titre, *Enquête sur l'exposition des êtres humains aux contaminants dans le milieu : Un guide communautaire*

Printed on recycled paper.

FOREWORD

Individuals and communities are becoming more aware of the relationship between their health and the environment. *Investigating Human Exposure to Contaminants in the Environment* consists of two handbooks that provide information to assist communities in understanding this relationship. *A Community Handbook* will help you carry out a descriptive exposure assessment and develop a health profile of your community. *A Handbook for Exposure Calculations* describes the general methods followed for calculating human exposure to environmental contaminants. These handbooks have been prepared by the Great Lakes Health Effects Program of the Health Protection Branch, Health Canada.

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ACKNOWLEDGEMENTS

Investigating Human Exposure to Contaminants in the Environment: A Community Handbook has been prepared by the Great Lakes Health Effects Program of the Health Protection Branch, Health Canada. A number of people have contributed to the preparation of this handbook. These people are: Douglas Haines, Jennifer Rae, Andy Gilman, Lynn Andrews, and Mary Hegan of the Great Lakes Health Effects Program, Rod Raphael and Barry Jessiman of the Monitoring and Criteria Division, and Brian Ahier of the Environmental Radiation Hazards Division, all of whom are with the Environmental Health Directorate of Health Canada. The following people have reviewed this handbook: Elaine Easson, Danny Epstein, David Kane, Tony Myres, Mark Richardson, and Keith Rodgers.

The illustrations and photos in the handbook are from a variety of sources. Figures 1, 2, 4, 5, and 6 were created for this handbook. Figures 3 and 7 are from *A Vital Link*, published by Health and Welfare Canada in 1992. Except where individually credited, all photographs, including the cover, were provided by Health Canada.

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INTRODUCTION

Purpose of Handbook

In recent years, there has been a tremendous increase in people's awareness of environmental issues and a growing concern over how their health is affected by their environment. However, there has been little guidance and no standard practical approaches on how they can address these issues in their communities. Consequently, this handbook has been prepared to provide communities with a tool to assess issues of health and environment and to understand the process for gathering and interpreting information when they have such concerns. With this knowledge, communities can have a greater role in the process of investigating environment and health issues that affect them.

*For more information on Remedial Action Plans and Areas of Concern, see **Part B: Background Information**.*

This handbook describes the step-by-step processes that can be followed in performing an exposure assessment and a health profile of a community. It has been prepared primarily for communities in the Great Lakes Basin in Ontario in order to provide Remedial Action Plan teams with guidance to address issues of health and the environment in their Areas of Concern. This is reflected in the case studies described in **Part A** and in the resources identified in **Part C**. However, the methods are general and can be used in any community concerned about people's exposure to environmental contaminants.

What's realistic to achieve?

The types of assessments described in this handbook represent the first pass at investigating community concerns about exposure to environmental contaminants or the health of its residents. These studies will not likely answer all the questions but they can help communities identify how people are exposed to environmental contaminants, what health issues are important and where gaps in data and knowledge exist. This information will assist them in addressing their concerns in more depth and establishing priorities for more detailed evaluations if deemed necessary.

What Is an Exposure Assessment?

An exposure assessment is a study of how people in the community come into contact with environmental contaminants. It examines how much of which contaminant people are exposed to. It does so by tracing the pathways from the source of the contaminant through the environment to the people that might be affected. These exposure pathways may lead through the air, the water, the soil, food or any combination of these.

Who should be involved in these investigations?

A great deal of work and motivation is necessary to complete these types of investigations. Frequently, such investigations are initiated by concerned citizens from the community. A realistic approach is to assemble people with the appropriate skills and expertise to share the workload through a task force or committee. Both lay people and experts will need to work together throughout the process. Committee members may include public health professionals, epidemiologists and statisticians, toxicologists, environmental professionals, municipal politicians, clerks and interested volunteers from the community.

The Contents of the Handbook

Part A outlines the steps in investigating human exposure to contaminants in the environment. It describes the following steps:

How to get started:

- Investigating community concerns.

How to carry out a qualitative Exposure Assessment of contaminants in the environment:

- gathering the existing information;
- identifying all the potential sources of exposure;
- establishing the types, nature and amounts of contaminants involved;
- evaluating the exposure pathways;
- defining the potentially exposed population;
- assessing community exposure; and
- preparing an evaluation.

How to prepare a Community Health Profile:

- gathering the initial information;
- collecting and summarizing existing health information;
- collecting and summarizing other relevant information;
- finding community-based knowledge;
- preparing an evaluation.

How to decide what to do next:

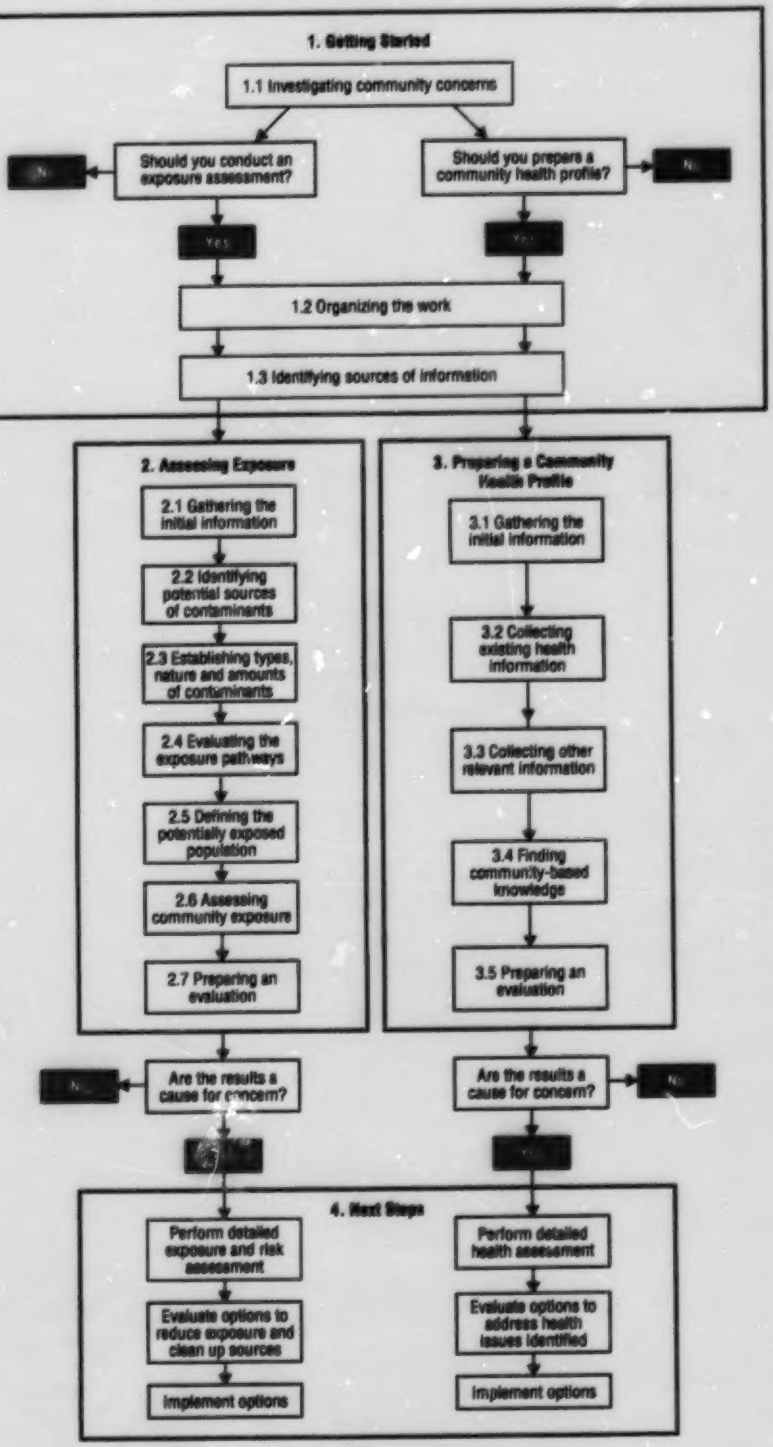
Part B: Background Information contains information on contaminants in the environment, a glossary and an explanation of common units of measurement.

Part C: Information Sources contains further sources of information including: some useful readings, a listing of organizations and agencies that can help, and a brief review of available computer databases.

What Is a Community Health Profile?

A community health profile is a kind of general medical check-up of the community as a whole. By gathering information on the health of many individuals, it is possible to create a picture of the health of the community. Through such a community survey, patterns will emerge: some diseases are more widespread than others, subgroups in the community suffer from different medical problems. By analysing these patterns and comparing them to other information such as lifestyles, places of work and health patterns for other communities or the Canadian population as a whole, the community health profile can pinpoint areas of concern and suggest where environmental contaminants may be a problem.

A STEP-BY-STEP APPROACH


1. Getting Started
1.1 Investigating community concerns
Should you conduct an exposure assessment?
Should you prepare a community health profile?
No
No
Yes
Yes
1.2 Organizing the work
1.3 Identifying sources of information
2. Assessing Exposure
2.1 Gathering the initial information
2.2 Identifying potential sources of contaminants
2.3 Establishing types, nature and amounts of contaminants
2.4 Evaluating the exposure pathways
2.5 Defining the potentially exposed population
2.6 Assessing community exposure
2.7 Preparing an evaluation
3. Preparing a Community Health Profile
3.1 Gathering the initial information
3.2 Collecting existing health information
3.3 Collecting other relevant information
3.4 Finding community-based knowledge
3.5 Preparing an evaluation
Are the results a cause for concern?
Are the results a cause for concern?
No
No
Yes
Yes
4. Next Steps
Perform detailed exposure and risk assessment
Evaluate options to reduce exposure and clean up sources
Implement options
Perform detailed health assessment
Evaluate options to address health issues identified
Implement options

The approach to performing an exposure assessment and a community health profile is summarized in this flow chart. The number in each box heading corresponds to the section in the text where detailed information is presented.

Assessing exposure and preparing a community health profile can be done separately. The decision will depend on the initial community concerns.

Investigating Human Exposure to
Contaminants in the Environment:

A Community Handbook

PART A: STEPS ON THE WAY

1. GETTING STARTED

1.1 Investigating Community Concerns

Many community concerns are triggered by the suspicion that there is a health problem in the community and that it is related to environmental contamination. At this point, action on investigating these concerns can be initiated by individuals or groups in the community, local politicians and public health agencies. The following are tips on how you, being any of the above, can investigate these concerns in your community.

Talk to People

The most important way of finding out how others in your community feel about the concerns you may have is to talk to as many people as you can. Find out if they have similar or different concerns. How important are these concerns to them?

- Talk to, or contact your friends, neighbours, other community members and elected officials to see if they share your concern.
- Talk to people from as many different neighbourhoods and backgrounds as you can. Concerns may vary between neighbourhoods and people of different backgrounds.
- Talk to people from municipal, provincial and federal agencies who work on environmental and health issues. They can provide a great deal of background information. Involve these people very early in your investigation. They are valuable resources both now and in the future.
- Identify who else should be consulted. For example, people who have lived in your community for a long time may have useful information on the health of the community and the environment in years gone by. Your local library may be a valuable source of data on the history of your community.

Once you have completed the initial step of talking to people, you will be in a better position to decide the extent of the "concern" and whether there is a need to investigate it more thoroughly.

1.2 Organizing the Work

If after talking to people, you feel that a more thorough investigation is needed, planning will be required. This section briefly discusses some of the planning issues that may arise. Having a plan allows you to focus your efforts on priorities, delegate the work and understand how the various tasks are linked. While planning at the beginning is very helpful, there will be questions that cannot be answered and new developments that cannot be foreseen. The initial plan should be flexible and will likely change as the investigation unfolds. When you view planning as an ongoing process, it makes it easier to create your initial plan.

Forming a committee

If you decide that a study is needed, you will likely be aware that such an effort usually requires more time and skills than one person can bring to the task. In other words, you will need assistance. Generally, it is better to include a core of interested people in the study right from the outset. By participating in the setting of goals and planning they will develop a sense of ownership and responsibility for the study. Other resource people can be brought in as necessary.

Forming a committee with a group of concerned people may also lend the investigation more credibility. When the results of the investigation are presented as the work of a committee, they are taken more seriously and it may be easier to ensure follow-up action. However, forming a committee also means giving up some control over the investigation. The more you include people with very different interests, the more you may have to compromise your initial goals.

Launching a committee can be straightforward. Invite those who share your concern, including friends, colleagues and people you met during the initial investigation to come to a meeting. The purpose of the meeting can simply be to discuss what you might do about your shared concern. At this point, people can be asked to commit to just this one meeting. The meeting itself will help clarify for the group and for each person what the next steps will be.

Sample Agenda for a First Meeting

- Welcome and purpose of meeting
- Present and approve agenda
- People attending introduce themselves
- Presentation: background and concerns
- Discussion questions:
    - What does each person want to achieve?
    - Is there enough concern to warrant further investigation?
    - What resources can each person bring to the investigation?
    - What role are people willing to play?
    - Who else should be invited to participate?
    - What should the role of the committee be?

    Note: a final answer to many of these questions will not be possible at this meeting. Instead it will be important to identify and assign tasks that will help to provide missing answers. The first meeting also allows people to get to know each other, and to discover where each person stands.
- Assign responsibilities for the next meeting.
- Pick a date, time and place for the next meeting.

Questions to consider

Planning initially requires decisions on a number of issues. Addressing the following questions early on will help you focus your efforts. Decisions can always be reconsidered as the situation changes.

What are your goals?

Clarity about your goals makes all decisions easier. When you think about goals, think broadly, about the changes or actions you want to see happen as a result of your work. Possible goals include:

- to discover if there is a link between contaminants and health effects;
- to discover if people are exposed to particular environmental contaminants;
- to raise awareness about the health effects of contaminants;
- to clean up specific pollution sources;
- to shed light on a possible pattern of illness;

- to discover how serious a particular contaminant of concern really is;
- to set clean-up priorities; and
- to give your community a clean bill of health.

In any group of people, goals will differ. As long as some central goals are held in common, it is possible to work together. It is worth spending some time discovering your common interests.

Is an investigation the best route for you?

An investigation of this kind often takes several years and may not give conclusive results. Before you plunge in, it helps to consider whether an investigation is the best way to achieve your goals. For instance, if your goals are oriented toward cleaning up a known pollution source, there may be more effective ways of spending your time. An investigation will not make decisions for the community. You and the community will still have to decide whether the results warrant further action, what type of action should be taken and who will provide the resources to clean up contaminant sources.

What will be the focus of the investigation?

The more focused your investigation, the less effort it will take. Your initial concerns and goals will help you decide on the big questions you want answered. To answer the big questions, it is usually necessary to examine a number of small questions. The investigation becomes a series of mini-investigations. Further research at each stage is focused on areas where the results indicate the largest potential exposures and/or health problems. Such an approach means you will not be able to map out the entire study in detail at the outset. Instead, you will be planning new stages as the results come in.

Exposure Assessment or Community Health Profile: Which one to do?

An important decision for you will be whether to do an exposure assessment or a community health profile. The decision will depend on the initial community concerns.

For example, there may be a source of contaminants in the community which people are concerned about. This may be the impetus to do an exposure assessment so that more can be discovered about the types of contaminants, how they travel through the environment, how people come into contact with them and to what extent people are exposed to them. On the other hand, people may believe that there is an unusual occurrence of a certain disease in their community. This may trigger the desire to perform an assessment of the health of the community, to find out if their initial concern is warranted.

What is the role of the committee?

There are a number of possible roles for the committee. Which role you choose will depend on your goals, and the time and resources committee members can bring to the task. The main roles are:

- decision making;
- collaborating with an agency or researcher undertaking part of the investigation;
- communicating about the investigation;
- seeking funding and other resources;
- organizing the work / planning;
- managing the business of the committee, meetings, etc.;
- record keeping;
- researching;
- report writing; and
- interpreting results.

The most important decision is the level of responsibility the committee wants to take for the study. The committee may want to stay in the driver's seat, or it may want to give control over the study to an organization that will carry out the work, with the committee continuing to advise that organization. An outside organization or government agency may also be approached to take on part of the work, especially the investigation itself - data collection, research, report writing and interpretation of the results.

When involving an outside organization in whatever role, seek to understand its mandate and the limits on what it is able to do. Consider how its mandate and ability to act fit with your goals, because any kind of partnership will require compromises.

Clarifying the role of the committee helps committee members understand what may be expected of them. A decision about your role can also help determine the structure of your organization, and its name.

Who should be on the committee?

Once again, consider your goals and the situation you are in. If you need consensus and cooperation from a broad cross section of the community, and such a consensus seems possible, then involving a diversity of community members is advisable. On the other hand, inviting someone to take part who is bitterly opposed to what you hope to achieve makes little sense. You may have to rely on the results of your investigation to change awareness in the community. People you invite to take part should also be interested in the issue, especially if you see the committee playing a very active role. In general, the broader your representation the more credible your results will be. Consider inviting the following representatives:

- interested citizens;
- people with technical skills you will need, such as a communications person and statistician;
- local politicians;
- staff of the Ontario Ministry of Health, such as the local Public Health Unit and the District Health Council;
- Ontario Ministry of Environment and Energy staff;
- Ministry of Natural Resources staff;
- Health Canada staff;
- people involved with the local Remedial Action Plan;
- community leaders;
- existing community groups;
- local university or college researchers;
- municipal health department staff;
- community health clinic staff;
- local physicians/health professionals with an interest in environmental health; and
- local industry representatives.

Involve expert and non-expert people in your study. The experience and knowledge of experts will be of great help. Non-experts can contribute with their knowledge of the community and can ensure that the community's concerns are communicated and addressed.

On a committee with broad representation, inequalities between members can arise when some members are able to devote more time to the investigation or have more professional expertise than others. This is often a concern for citizen members of the committee. Ways to address this issue include:

- creating and sticking to a mission statement based on your goals;
- being clear about whether important decisions require a consensus of the group or a simple majority;
- willingness on the part of those with technical expertise to share their knowledge and educate others on the committee;
- hard work on the part of citizen members to provide leadership and understand the complexities involved in this kind of project; and
- seeking out resources to assist members to devote more time to the project, such as funding to carry out specific tasks.

Expect new people, invited to join the committee, to want to re-examine some of the questions listed in this section.

What level of leadership and commitment are individuals willing to give?

An investigation of this kind often requires more time and work than anyone could have foreseen. Ask yourselves whether there is enough leadership and commitment in the group to see you through. If your doubts are very great, consider reducing the scope of your plans or make it a priority to find the resources and/or people needed to achieve your goals.

What resources are needed?

The experience of communities which have undertaken similar studies show that they can take up to two or three years to complete. A commitment of time and effort by everyone involved is needed.

What you will need depends on the type and scope of investigation you intend to do. For example, access to medical records, expertise in evaluating them and compiling statistics about the health status of the community are more necessary for a community health profile than for an exposure assessment. General categories of resources needed are:

- access to information - medical records, statistical records, information about contaminant sources, etc.;
- access to equipment such as computers, fax machines, copiers, etc.;
- funding for computer searches, research materials, long distance telephone, etc.;
- time of researchers, including experts in research science, statistics, epidemiology, toxicology, report writing; and
- time of those coordinating and communicating the investigation.

What resources are available?

Before you assess how realistic your goals are, consider what resources are available. Discuss people and organizations you know that can provide funding or in-kind contributions. Local government agencies may be persuaded to take on parts or all of the study. Research assistance can also be found at local universities and colleges, where professors and students are often interested in working on relevant local projects. Non-government organizations may have volunteers, office space and access to equipment. Sources of funding information are listed in **Part C: Information Sources.**

What solutions have other communities found?

Two case studies describing an exposure assessment and a community health profile are outlined in this handbook. The Sault Ste. Marie - St. Marys River Study of polycyclic aromatic hydrocarbons (PAHs) describes an exposure assessment. The Cornwall - Air Quality Study is an example of a community health profile.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

A diverse mixture of contaminants generated by industrial and municipal sources flows into the St. Marys River at Sault Ste. Marie. Technical and public concern has centred on PAHs because of high levels found in sediments and water, and because there are no health guidelines which could be used to assess the health risks of PAHs at levels found in the river. The issue of sustained exposure of the local community to PAHs in the river also needed to be examined. In order to decide on the priority of clean-up options for the Remedial Action Plan (RAP) process, a risk assessment based on PAH exposure was needed. (For more information on RAPs, see **Part B**)

The St. Marys River study was part of an established RAP process, with a technical team and a binational public advisory committee. The PAH work was suggested by the public advisory committee, and several stakeholder groups already active in the process contributed to the study.

Cornwall - Air Quality Study

The odour in the air, as a result of industrial emissions in the Cornwall area, has fuelled public health concern and has led to perceived connections between air emissions and respiratory disease or cancer. These concerns over health prompted the Cornwall Committee to look at health data rather than focusing on exposure to specific contaminants.

The Cornwall Air Quality Committee was formed as a result of concerns about air quality and odours in Cornwall. It began in response to a letter from the mayor published in the local newspaper asking for public participation and comment on actions to reduce contaminant releases at local industrial plants. The initial committee, comprising concerned citizens, called two public meetings and found support for a focus on determining whether air pollution was causing health effects. The committee identified the issues and the agencies which could supply data, and called on them to provide information or assistance as needed. In this manner, the committee facilitated the study by bringing interested parties in the community together. This committee has retained a very fluid membership and has accomplished a great deal.

Three Strategies

To guide the work of your committee, you may find it helpful to develop three strategies. Preparing and coordinating the implementation of each strategy can be done by sub-committees.

Study Strategy

The study strategy can be developed based on your goals, the suggestions in the handbook and your preliminary discussions about the focus of the investigation. It may take the form of a series of mini-investigations - with details on tasks, who will do them and when - filled in as the results of the previous mini-investigation become available. This approach saves spending much effort researching questions that yield no conclusive results. For instance in Sault Ste. Marie, a river water use survey identified that people used the river for swimming only. As a result, it was not necessary to research the potential effects of using the water for drinking or watering gardens.

Communications Strategy

The topic of health and environmental contaminants can be of great concern to people, especially when they suspect their own health is affected. Communicating about your investigation in a manner that has been well thought through will help to avoid reactions you did not intend. A communications strategy, that evolves from your goals and the study strategy, describes who will communicate what, how and when. **Section 4: Next Steps**, gives further information on developing a strategy.

Fundraising or Resources Strategy

Putting some thought into how you will find the resources you need makes success more likely. A resources strategy sets out what you need, sets priorities and describes the steps to appeal to potential funders you have identified.

Planning tools

The logical organization of information is also a part of planning. The following three tools may be of use to you at various points:

- A timeline shows when each task starts and finishes on a calendar. It helps you to set priorities, schedule work in a logical order and determine how realistic any deadlines may be.
- A budget may show how much time people will require to complete tasks, the amount they are paid and other expenses associated with each task. Budgets are often needed to apply for funds, and to manage the spending of any grants you receive.

- Record keeping in the form of minutes from meetings and an accounting of resources spent (including volunteer hours) makes future planning easier. New plans can be based on decisions already made and using past experience in similar situations.

It is possible to devote too much time to planning. Avoid the temptation to come up with very detailed plans at the outset. What will serve you best is a general framework that keeps your work focused and the ability to be flexible as your planning needs unfold.

1.3 Identifying Sources of Information

There are various sources that can help you to gather the data, information and knowledge needed for carrying out exposure assessments or community health profiles. The following sources of information are described in this Section:

- government agencies (municipal, provincial and federal);
- other community residents;
- universities and research centres;
- owners/operators of industries or municipal facilities;
- community and environmental organizations and associations;
- libraries and archives; and
- environmental professionals.

The information that can be obtained from these sources, whether private or public, will vary according to their policies and resources available for responding to public requests. There may also be costs associated in obtaining information, as some agencies will charge fees to cover their costs of responding to these requests. The sources of information are described in more detail below.

Government Agencies

There are several government agencies that are responsible for different aspects of the environment and health. **Municipal and regional governments** are usually responsible for land use planning, as well as sewage treatment and the collection and disposal of household garbage. In some cases, sewage treatment is a provincial responsibility. However, most municipalities should be able to provide you with information on zoning and the locations of various possible point sources of contaminants, including industries and old and active waste disposal sites. An important point of contact may be the Commissioner of Planning.

For the **provincial government**, begin by contacting the regional office of the Ontario Ministry of Environment and Energy closest to you. It may also be appropriate to contact the offices of the Ontario

Ministry of Natural Resources and the Ontario Ministry of Health for your region. The phone numbers of all these Ministries will be in the blue pages of the telephone directory.

The Ministry of Environment and Energy and the Ministry of Natural Resources have much information on the environment in your area. This may include data on water and air quality, soil contamination and on the health of the fish and wildlife in your area. Ask for a copy of the *Guide to Eating Ontario Sport Fish*. This will give you a general idea whether contaminants are a problem in freshwater fish in nearby lakes or rivers. Both Ministries are also involved in coordinating Remedial Action Plans in the Areas of Concern around the Great Lakes.

The public health unit in your region may also have information on water quality at beaches used for swimming and other recreational activities. Public health units may also have prepared health status and environmental assessment reports for your community. Begin by contacting the Medical Officer of Health for your regional public health unit.

District Health Councils have been delegated, by the Ontario Ministry of Health, the responsibility for health planning in each region of the province. They maintain, or have access to, a great deal of health information on the communities they serve.

Remedial Action Plan (RAP) technical teams exist for each of the Great Lakes Areas of Concern in Ontario. These teams are responsible for developing and implementing plans to clean up the Areas of Concern. They have gathered a variety of environmental and other data as part of their planning. The important point of contact is the local RAP coordinator (see **Part C** for addresses and phone numbers).

The **federal government** will also have information on the environment in your area. Contact the regional office of Environment Canada nearest you. The Canadian Wildlife Service of Environment Canada may have information on contaminant levels in some wildlife species to supplement information from the Ministry of Natural Resources. The Atmospheric Environment Service, of Environment Canada, can provide you with information on prevailing wind directions, climate, and some air pollution results. The Environmental Conservation Service may also be able to provide information and advice on regulations and guidelines.

The Environmental Health Directorate of Health Canada, through the Great Lakes Health Effects Program, is another source of information, particularly with regard to approaches and methods used to evaluate the exposure to and the risk from environmental contaminants. They can provide guidelines for contaminants in air, water and dumpsites, and advice for health protection and promotion, drinking water safety, radiation and other issues. The Food Directorate can provide information on contaminants in food and advise on effective ways to protect health. The Laboratory Centre for Disease Control has access to large health databases and has expertise in methods of conducting human health studies and interpretation of health data. The Canadian Centre for Health Information of Statistics Canada also maintains and publishes a variety of health statistics for all regions in the country.

Other Community Residents

People living or working near the potential sources of environmental contaminants are an important source of first-hand information based on observation and experience. They can be particularly helpful in identifying general patterns and the sequence of events at a particular factory or site. Former residents can also provide useful information about what happened in the past.

Remember that factual descriptions of what happened or of how the environment changed are more useful than unfounded claims or accusations. Check the information you get from individual community residents, by talking to as many different people as possible. With their permission, keep notes of all conversations.

Universities and Research Centres

Many universities and research centres have faculty members who are knowledgeable about the environment. McMaster University and the University of Toronto have joined together to form the Institute of Environment and Health. Several universities have specific environmental studies programs (University of Guelph, University of Toronto, York University, University of Waterloo, Ryerson Polytechnical University). Ryerson Polytechnical University also has a School of Environmental Health and others have schools of Public Health or Community Medicine (University of Toronto, University of Ottawa, McMaster University, Queen's University, University of Western Ontario). These resource people may be able to offer you suggestions and guidance. If you can interest faculty members in your study, they may encourage students to become involved and to help you, as part of their course work. Many students value opportunities to investigate real-life problems and to apply some of the theoretical ideas that they are learning. Some universities and research centres may have facilities, such as laboratories, libraries or resources centres, that could be of use in your study.

Owners/Operators of Industries or Municipal Facilities

Owners or operators of industries (such as manufacturing plants) or municipal facilities (such as waste disposal sites and sewage treatment plants) have information that could be useful to you. Establish who is in charge of the day-to-day operations of the site or facility or for its maintenance if it is no longer in operation. Some companies have a manager or an office responsible for the environmental management of the facilities operation. Try to make an appointment to meet with them and explain your concerns, using whatever information you have collected already. Ask for specific additional information, explaining what you intend to do with it. It may or may not be easy to get the information you want from these facilities. Follow up on your meeting with a written request for specific information and thank them for information already received.

Community and Environmental Organizations and Associations

Many community and environmental organizations are actively working on issues related to waste management, toxic and hazardous materials, community health, etc. These groups will often be very helpful in providing you with advice, information and contacts. For a list of local groups in your area contact one of the larger environmental organizations, such as Pollution Probe, Greenpeace, Great Lakes United, the Ontario Public Interest Research Group (OPIRG) or the Canadian Environmental Network. Also try health organizations which work on issues related to community health, such as the Lung Association and the Healthy Communities Project.

Addresses and phone numbers for these and other sources of information are found in ***Part C: Information Sources****.*

Libraries and Archives

A wide range of reference materials are available to help you with your investigation. Libraries often have (or have access to) reference books on the environment as well as on environmental contaminants. Local archives will have maps and aerial photographs that you can use, as well as historical information on your community.

Environmental Professionals

There may be environmental professionals living in or nearby your community. These include environmental consultants, ecologists and environmental engineers. Many companies have occupational health and safety staff. Some local community health centres and public health units have expertise in occupational health and safety and environmental health. Many are willing to volunteer their time and expertise. Ask people in your community if they know of anyone with relevant knowledge and experience and then make an appointment to see them.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

In order to identify the sources of information available to address the PAH health issue, Health Canada, in consultation with the St. Marys River Remedial Action Plan team, called a meeting of the various stakeholders in the community. These stakeholders spanned public and private sector agencies and included the Ontario Ministry of Environment and Energy, the Ontario Ministry of Labour, the Great Lakes Health Effects Program of Health Canada, the Algoma Health Unit, Algoma Steel, community residents and representatives of the Native community in the area. These representatives shared information at their disposal, identified gaps in knowledge and devised an action plan to address the PAH health issue.

Cornwall - Air Quality Study

The Cornwall Air Quality Committee called on a number of sources for information. These included the local Lung Association office, the Great Lakes Health Effects Program of Health Canada, the Eastern Ontario Health Unit, local businesses and industries, and community residents. These sources were identified as the committee developed its network of contacts through discussions. More sources were identified as work progressed.

2. ASSESSING EXPOSURE

This Section of the handbook provides guidance on how to assess your community's exposure to contaminants in the environment. It emphasizes exposures to toxic chemicals that remain in the environment over long periods of time. To get a comprehensive picture of exposure in your community, the following activities should be considered:

- gathering the initial information;
- identifying all the potential sources of contaminants;
- establishing the types, nature and amounts of contaminants involved;
- evaluating the exposure pathways;
- defining the potentially exposed population;
- assessing community exposure; and
- preparing an evaluation.

These are described in more detail below.

We are all exposed to low levels of many environmental contaminants over our lifetimes. Even though suspected in many cases, health problems due to exposure to low levels of contaminants in the environment are difficult to prove. The effects on health that may result from exposure to selected environmental contaminants are described in ***Part B: Background Information****.*

2.1 Gathering the Initial Information

One of the first steps in assessing your community's exposure to contaminants in the environment is to gather relevant initial information. This includes:

- recording and documenting the concerns being expressed;
- collecting data from first-hand observations;
- interviewing people who are knowledgeable about the local environment; and

Thomas Rohn

- gathering information from government, industry and other agencies.

These are described in more detail below.

Recording and Documenting the Concerns

First, record and document people's concerns about environmental contaminants in your community. Why are people concerned? Prepare a summary, including the events or circumstances that caused the concern and who was involved. You should also note where concerns are shared by several people, and where they are not. It is helpful to know whether just one person was concerned, or a hundred people. Similarly, does everyone agree on the concern, or are there several different opinions?

*There are many sources of contaminants outside your community that could affect people living in it. These include chemicals or microbiological organisms carried into your community by wind or water currents or wildlife. This handbook focuses on assessing exposure from contaminant sources **in** your community.*

People's concerns are very important and should be addressed. The information that you gather may help you distinguish whether their concerns are based on "actual" or "perceived" health problems in their community.

Collecting Data from First-Hand Observations

Using the information you have recorded about the community's concerns, do some research yourself. If the contaminants have a known source in the community, try to make an appointment with the manager or environmental officer to visit their facilities. How are the sites managed and what is the condition of the facility? Record your observations carefully.

Interviewing People Who Are Knowledgeable about the Environment

Talk to local people who are aware of the environment in and near your community. For example, try members of a local "birding" or field naturalists club, or local farmers or anglers. Ask them if they have noticed if the health of the environment has changed, and if so how. Do they suspect anything that could be causing these changes? Keep a record of their remarks.

Gathering Information from Government, Industry and Other Agencies

Contact the relevant government, industry and other agencies and begin to gather information on environmental quality in your area. Include information on air quality, water quality, the presence of contaminants in fish and wildlife, prevailing wind direction, water drainage patterns, soil types, soil contamination problems, previous land use, etc. Synthesize the information so that you have an overview of the environmental quality of your area. Focus on finding information that sheds more light on the concerns you have identified.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

The St. Marys River Remedial Action Plan team had a great deal of environmental and contaminant emission data at its disposal from various agencies participating in the Remedial Action Plan process. Although enough information existed to identify contaminants of concern in general terms, the team identified the need for current data on PAH levels in the river water and sediments in order to better assess the community's exposure and risk to health. It also felt that not enough was known on who uses the river, for what purposes and how often. Two studies were initiated to obtain this missing information: a sediment and water sampling survey measuring levels of PAHs in samples collected from various sites in the river; and a water use survey during which Ontario Ministry of Environment and Energy summer students and staff used a written questionnaire and door-to-door interviews to obtain an accurate picture of residents' use of the river for purposes such as bathing, showering, drinking or gardening.

2.2 Identifying All the Potential Sources of Contaminants

The second step in assessing exposure is to identify all the potential sources of contaminants in and around your community.

Possible sources to consider include:

- industries;
- waste disposal sites still in operation (either solid waste or hazardous waste sites);
- farms;
- sewage treatment plants;
- abandoned factories and waste disposal sites or other contaminated sites; and
- "non-point" sources, such as street runoff and areas where pesticides, herbicides or fertilizers are used.

Get as much information as you can on these and other possible sources. Use available maps and aerial photographs to identify their locations. Mark on the maps the location of nearby houses, schools, water supply wells or intakes, and special environmental features such as land drainage, rivers, streams, fish-spawning areas and prevailing wind direction. Include all possible sources on one map of your entire community, so that you can see how different sources relate to each other. You may also need several larger scale maps of individual sources and their surroundings. Identify the facilities or sites about which concerns have been expressed.

"Point" and "Non-Point" Sources

Environmental contaminants can come from two different types of sources. Point sources are single, easily identified sources of pollution. Examples are large smokestacks or the waste water discharge pipe of a sewage treatment plant. When small amounts of environmental contaminants from many sources combine to create a large problem, the sources are considered to be "non-point." Examples of non-point sources are pesticide and fertilizer runoff from farms or the air pollution from cars.

Contact provincial (Ministry of Environment and Energy) and municipal (Public Works) officials for information on possible point sources of contaminants in the area. This includes any information on licences or permits to operate facilities. Other information to ask for includes the types and amounts of substances discharged into the environment, as well as previous uses of various sites in the area.

Prepare a written description of the possible sources to complement the maps or aerial photos. Include information on the uses of the site or facility, the processes or procedures used, the numbers of people employed, how long the factory or site has been there, any known accidents or spills involving contaminants and any other relevant information.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

Sources of contaminants were identified from the Ontario Ministry of Environment and Energy data on concentrations in air and water and from data on emissions from sewage treatment plants and industrial effluent streams. The major source of PAHs in the St. Marys River was found to be the local steel mill.

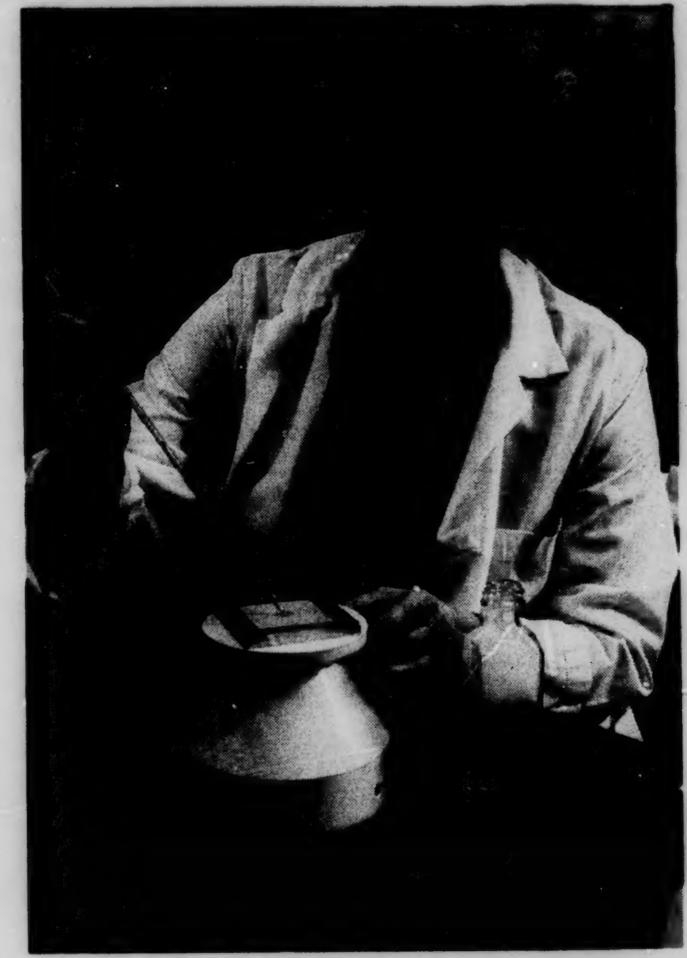
2.3 Establishing the Types, Nature and Amounts of Contaminants Involved

If you would like more information about the types of contaminants in the environment, see ***Part B: Background Information****.*

It is important to establish the types, nature and amounts of any contaminants involved and how they are used, stored, manufactured and disposed of at each source you have identified. Some of this information may have already been collected when you were finding out about the potential sources of contaminants.

First, find out about the types of contaminants normally associated with the sources you have identified. For example, sewage treatment plants usually use chlorine to disinfect the waste water. Identify the form or state of the substance. Is it a gas, a liquid or a solid? Does it have an odour? Is it a single contaminant or a mixture of contaminants? Library work combined with data gathered from other sources will enable you to do at least a partial inventory for each source of environmental contaminants. Be as specific as possible. Include information on the amounts and degree of hazard of any contaminants involved.

Contact the managers, operators or environmental officers of the facilities of concern to discuss the types of hazardous materials used or stored there. Find out what's being discharged or released into the



environment. The amount and type of information given in response to requests by the public will vary according to the policies of the facilities. Facilities that use or store hazardous materials are required to label all hazardous materials on site and to retain copies of the "Material Safety Data Sheets" (MSDSs) for each substance. Ask the facility managers if they can provide you with their MSDSs. Some may be willing to work with community groups and to provide this information. Some operations may maintain up to several hundred MSDSs. In these cases, it will be necessary to be as specific as possible about the types of substances of greatest interest. Document your findings clearly, recording the names, dates and times of your appointments and what observations were made.

If you think chemical analysis would be helpful to establish the specific nature and/or concentrations of individual contaminants, try consulting with the regional office of the Ontario Ministry of Environment and Energy or your local Medical Officer of Health. Commercial labs can also be found in the yellow pages of the phone book. They may suggest ways to collect the appropriate sample and have it analysed. Because it can be fairly expensive, consider chemical analysis of samples after you have an idea of what you are looking for.

Find out if there has been any local human contact with any hazardous substances. Who handles them and how? Do they wear any protective equipment?

Add this information and data to your written description of the potential sources of contamination. Where appropriate, use figures, tables, drawings and diagrams to illustrate the text.

Material Safety Data Sheets

Material Safety Data Sheets (MSDSs) contain information about a substance's toxicity and hazards and are required under the Workplace Hazardous Materials Information System (WHMIS) regulations of the Ontario Health and Safety Act. *Although MSDSs will not tell you how much of any substance is on the site, they will give you valuable information about the nature of the materials and their toxicity. Be aware that, at times, the final products and their by-products derived from the manufacturing process may have little resemblance (and possibly different toxicity) to the original material. MSDSs also may not provide information on the health effects of long-term exposure to low levels of these substances. A sample MSDS is presented in* ***Part B: Background Information****.*

What is a persistent contaminant?

When contaminants are released into the environment, the length of time they stay in the environment becomes an important concern. A substance that is relatively toxic can be considered a minor hazard if it breaks down quickly into non-hazardous substances before people can be exposed to it. The opposite is also true: a mildly toxic contaminant that remains for a long time in those parts of the environment where humans can be exposed to it can be a serious concern. Some toxic chemicals, such as lead or cadmium, cannot break down. Others can theoretically break down, but only under extreme conditions (such as the heat of an incinerator) not normally found in the environment. Substances that remain in the environment for long periods are called persistent contaminants. Those that are also hazardous are often called "persistent" toxic substances.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

PAHs had been identified previously as the contaminants of concern in the St. Marys River. The nature and levels of PAHs were established by the chemical analysis of samples collected at various sites in the water and sediments survey. Ontario Ministry of Environment and Energy standard collection and analytical techniques were followed in this survey. The sampling sites were selected according to community knowledge of areas of active recreational water use, which was based on the water use survey questionnaire and interview responses, and advice from the Algoma Health Unit and representatives from the Native community.

2.4 Evaluating the Exposure Pathways

Once you have identified the types, nature and amounts of contaminants involved, you should evaluate how each one moves in the environment and how people could be exposed. Is the substance likely to be found in water and enter the municipal drinking water system? Does it evaporate easily into the air and as a result, is likely to be inhaled? Does it concentrate in local fish or in food grown by community residents? Does it remain in the environment for a long time or does it break down quickly? When living organisms absorb the contaminant, do they store it in their tissues, break it down or eliminate it quickly? If it is broken down, are any of the resulting new substances of concern?

If you would like more information about the sources, movement and fate of contaminants in the environment or about pathways of exposure, see ***Part B: Background Information****.*

Find out as much as you can about the substance's behaviour in the environment so that you can establish the most important exposure pathways. This will probably require a fair amount of research work in a library. Alternatively, someone with a background in environmental toxicology or chemistry could be very helpful at this point. Refer to FIGURE 1 (next page) and FIGURE 4 (in **Part B: Background Information**) for more information on exposure pathways.

Using the information you have gathered on exposure pathways, try to find out the level or concentration of the contaminant in each pathway. There may be information from testing of local soil, water, air and food available. For important pathways of the contaminants of greatest concern, you may want to consider further chemical tests if the information you need is missing.

After your investigation of potential exposure pathways, you should prepare a written description of your findings. Summarize what you consider to be the most important exposure pathways and why.

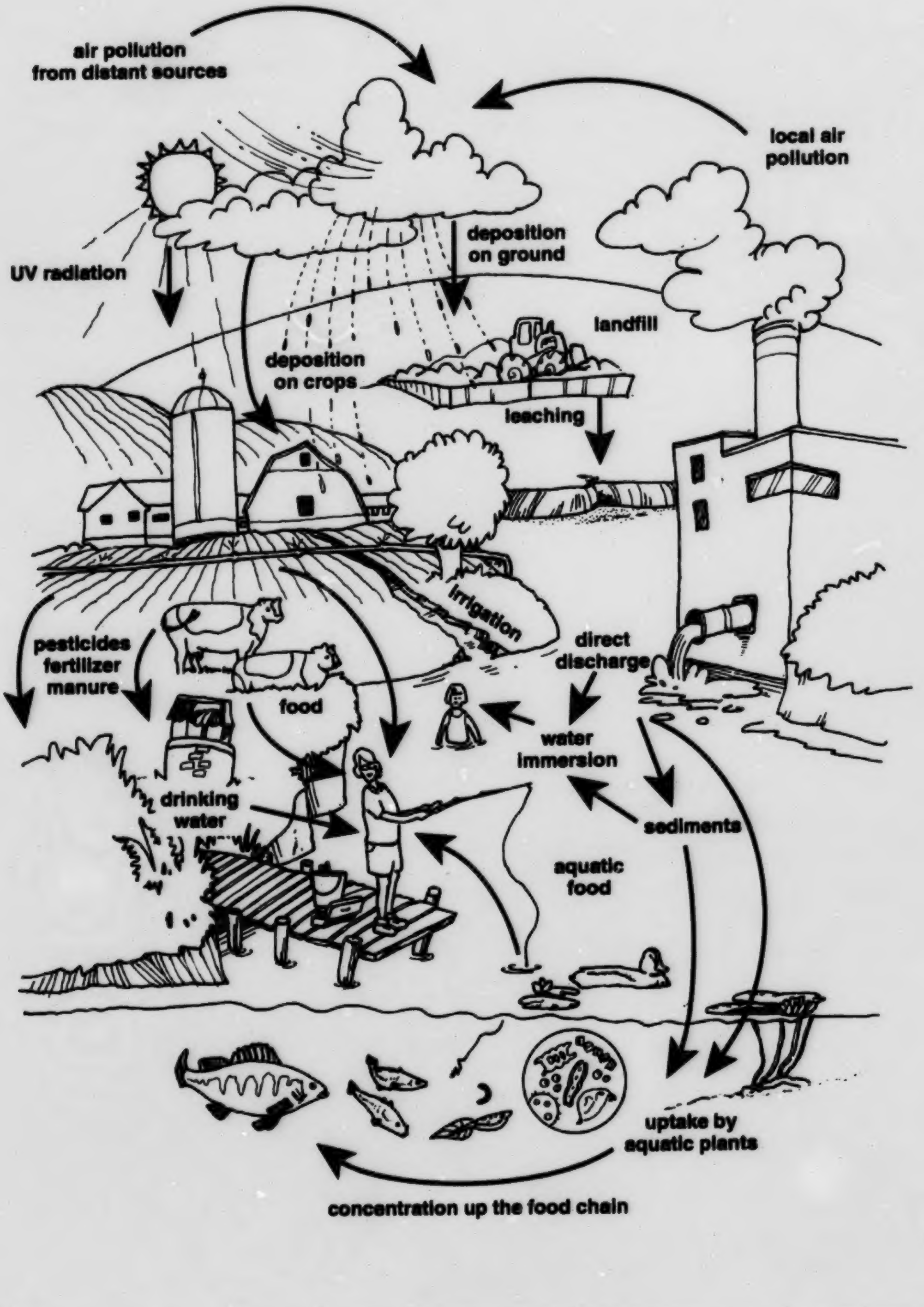
CASE STUDY

Sault Ste. Marie - St. Marys River Study

The main concern expressed by the community was from exposure to PAHs at recreational beach sites. Based on the advice of technical experts, skin contact (i.e., dermal route) was thought to be the most important route of exposure during recreational use of the river, since PAHs breathed in as vapours or ingested through food or water were considered minor contributors to exposure in this situation. Therefore, risk assessment efforts focused on the pathway specific to exposure to PAHs through skin contact with river water and sediments.

FIGURE 1:

Exposure Pathways


air pollution from distant sources
local air pollution
UV radiation
deposition on ground
landfill
deposition on crops
leaching
irrigation
pesticides fertilizer manure
direct discharge
food
water immersion
drinking water
sediments
aquatic food
uptake by aquatic plants
concentration up the food chain

2.5 Defining the Potentially Exposed Population

The next step is to identify who could have been exposed to the contaminants you have identified. The group of people who may have been or may be exposed to the contaminant is called the potentially exposed population. Defining the potentially exposed population requires a knowledge of the community itself.

In general, there are two groups of people who could be exposed:

- workers employed at the site or factory; and
- people living, working, going to school or taking part in recreational activities in the community.

Air can contribute up to 10% of our exposure to some persistent toxic substances.

While worker exposure can be a serious concern, this handbook focuses on the second group - community exposure. In Ontario, the *Occupational Health and Safety Act* is designed to protect workers' health, and there are several mechanisms in place, such as joint worker-management committees and the Workplace Hazardous Materials Information System (WHMIS) to reduce workplace exposure to contaminants.

To define who is or could be exposed, consider the exposure pathways you have identified.

Water

To define the potentially exposed population for a water exposure pathway, consider who could have consumed contaminated drinking water or come into contact with polluted recreational water. Could the contaminant have entered the drinking water supply or be in a nearby river or lake? The potentially exposed population could be defined as everyone using the particular drinking water supply (either a private supply, such as a well, or a municipally treated supply) or everyone visiting a particular river or lake and coming into contact with the water through recreational activities such as swimming or water skiing.

Air

To define the potentially exposed population for an air exposure pathway, consider the source of the air pollution, the prevailing wind direction and the geographical area affected. The people living, working or going to school in the area near the source and those living downwind from the source could be defined as the potentially exposed population.

Food

To define the potentially exposed population for a food exposure pathway, consider who eats the contaminated food. In those cases where a local food exposure pathway is a significant concern, it is often anglers and their families who eat contaminated fish, and hunters who eat wild meat from local moose, deer and ducks, who constitute the potentially exposed population. Also consider locally grown food, as compared to food "imported" into the community as a potential source of exposure.

Soil

To define the potentially exposed population for a soil exposure pathway, consider who is in contact with the contaminated soil. People living or working near or in an area with contaminated soil or those using the site for recreation may be at risk of exposure. Young children, who tend to put dirty objects in their mouths, may be potentially exposed to contaminated soil.

Did you know that the majority of human exposure to many persistent toxic substances, such as PCBs, is through food, particularly for people who eat a lot of contaminated wild game and sport caught fish?

Be as precise as possible in identifying the potentially exposed population. In particular:

- Can you define the geographic boundaries of the exposed populations? In other words, can you say where the potentially exposed population(s) lives, works or goes to school? (use a map)
- Is exposure limited to people doing a particular activity (e.g., fishing, smoking, eating a particular type of food)?
- Is exposure limited to a particular group within the community that can be defined by common age, sex or ethnic background?

The answers to these questions will help you to identify the potentially exposed population.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

The water use survey established that shoreline residents did not use untreated river water for drinking or for watering vegetable gardens, and that the only relevant exposure to PAHs was from recreational activities such as swimming and bathing. Therefore, recreational swimmers and bathers were identified as the potentially exposed population in this situation.

2.6 Assessing Community Exposure

In order to assess your community's exposure to contaminants in the environment, you must have a general idea about the **level or concentration** of contaminants in the environmental media (i.e., air, water, soil, food) of each exposure pathway. To do a simple exposure assessment that does not involve complex mathematical calculations, it is often enough to know whether the concentrations of contaminants in each pathway are above or below existing criteria or standards. For example, how do the levels of mercury in sport caught fish in your area compare to guidelines set by the Ministry of Environment and Energy? Are the levels of specific contaminants in soil and water above or below criteria or standards set by the Ontario Ministry of Environment and Energy? Note that criteria and standards set for the maximum tolerable levels of contaminants in the soil depend on the intended use of the area. For example, the allowable levels of contaminants in soil will be lower if an area is intended for agricultural, residential or parkland use compared to commercial or industrial use, because people contact will be greater.

The methods for calculating people's exposure to environmental contaminants are described in detail in Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations.

Regulations, Standards, Guidelines and Levels: What's the difference?

A regulation is a legally enforceable limit on the amount or concentration of a substance. Standards, such as those for different air pollutants, and the penalties for exceeding them are usually set out in a regulation. Exceeding the standard set out in the regulation could result in unacceptable harm to human health or the environment and lead to penalties. Guidelines are advisory limits, above which there are grounds for concern, but they are not legally enforceable. Finally, levels are simply amounts or concentrations of a substance.

CASE STUDY

Sault Ste. Marie - St. Marys River Study

A preliminary exposure assessment was carried out only for those exposed to river water and sediments by swimming and bathing. For a complete health assessment, contaminant levels and other information on food and air exposures would be needed. However, in this case, estimates of the risks to health, due to exposure to PAHs from swimming at various sites in the St. Marys River, were developed. The results of the risk assessment indicated that the risks of developing cancer, due to exposure to PAHs from swimming in all inshore swimming areas, were negligible. Only two offshore sites posed some risk to health, but it was unlikely that people would swim in those areas, because of their distance from shore and the strong currents found there.

2.7 Preparing an Evaluation

Once you have finished your exposure assessment, you may want to prepare a written evaluation. It is a good way of summarizing and documenting what you have done and what you have found. This following information could be included in your report:

- a description of the problem or concern you were investigating;
- the objectives of your exposure assessment;
- the methods and procedures used;
- the results and findings;
- your interpretation of the results and findings;
- conclusions and recommendations; and
- a summary that can be distributed more widely.

In your report, present all of the relevant information you have collected. Where appropriate, include maps, figures, tables and illustrations. When you have completed your report, ensure that it receives widespread distribution in the community, and send copies to all people you have consulted. Ask for their comments. Hold a community meeting or think of other ways of distributing your findings.

CASE STUDY

Sault Ste. Marie - St.Marys River Study

A number of reports have been prepared as a result of the St. Marys River Study. Environmental levels of PAHs and other contaminants, measured in samples collected for the water and sediments survey, have been presented in various technical reports. A report on the water use survey and a risk assessment report outlining the lifetime risk to health of swimming in the St. Marys River have been prepared.

3. PREPARING A COMMUNITY HEALTH PROFILE

This Section provides guidance on how to prepare a profile of the health of your community. A community health profile examines the health of the entire community rather than of individual cases. Individual cases may be useful to illustrate a particular problem area, but are of limited value in determining trends in the health of the wider community. By comparing these health trends with other information about your community, and with health trends in other communities, you will get a better sense of whether your initial concerns about the health effects of environmental contaminants are supported.

The amount of information and research available may seem overwhelming. It will help to approach each information source with the simple question: will it help shed light on the concerns identified in the initial exploration of the issue? If you cannot answer the question, it may be worthwhile to seek advice before undertaking further work. Your local Medical Officer of Health and the provincial Ministry of Health are good starting points for advice on how to carry out your study.

In any type of community health profile related to a concern about contaminants in the environment, there are several issues that should be considered, including:

- confidentiality of information;
- lack of relevant data or inconsistency in reporting;
- sources and form of health information; and
- the difficulty of "proving" that an environmental exposure caused a health effect.

These are discussed below.

Confidentiality of Information

Often, detailed health information will be difficult to obtain. Health professionals and hospitals take care to keep patient information confidential, so that anything you are given will not contain the names or addresses of the individuals concerned. If you do any type of survey, be prepared that some individuals will be unwilling to discuss their own or their family's health problems, because they may view this as an invasion of their privacy. In the interest of confidentiality, you should not give out any information on individuals, except to the individuals themselves.

Finding Relevant Data

Although physicians and hospitals report on several major health diseases and symptoms, information on common health problems, such as headaches, nausea or skin rashes, is not kept systematically. The usual types of health information that are available are:

- *mortality* records, which indicate the cause of death for everyone who has died in the community;
- records of *congenital anomalies* in babies, which indicate trends in birth defects;
- *cancer incidence* records showing the number of cases of different types of cancer; and
- *hospital admission data* showing the medical reason for each patient's hospital stay.

In all cases, information that could be used to identify individuals, such as names and addresses, will have been removed to maintain confidentiality. There may also be some differences between physicians and hospitals in how they report this information.

Sources and Form of Health Information

The important sources of information that you will need to prepare a community health profile include:

- databases that contain information on the health status of your community, including the mortality database, the Ontario Cancer Treatment and Research Foundation (OCTRF) database, the congenital anomalies database and the Canadian Institute for Health Information (CIHI) database;
- government agencies, especially the Ontario Ministry of Health, Health Canada, Statistics Canada and your local Medical Officer of Health;
- health care professionals in your community, including physicians, nurses, homecare workers, public health professionals and midwives;
- universities, colleges and research centres;
- environmental and community organizations;
- environmental and health professionals in your community, including consultants, epidemiologists, toxicologists and environmental health specialists; and
- industry occupational health and safety professionals.

Many of these information sources were described in more detail in Section 1.3. Addresses and phone numbers of some of these sources are found in **Part C: Information Sources**.

These days, most health information is computerized and uses technical jargon such as "ICD" codes, the "SMR" and "statistical significance." Experts in universities, public health units, the provincial Ministry of Health and Health Canada with a background in epidemiology or statistics can explain this information.

"Proving" that an Environmental Exposure Caused a Health Effect

It is usually very difficult to prove that an environmental exposure caused a health problem in a community. This is because:

- We are all exposed to many contaminants throughout our lives and different contaminants may cause similar health effects.
- Environmental exposures are usually too low to cause immediate and easily identified health problems.
- Several lifestyle activities (such as smoking, alcohol consumption and the use of medications or other drugs) can act as *confounding factors* that is, they can interfere with our ability to relate health effects to environmental exposures because they cause the same effects.
- There can be a long period of time between exposure to a contaminant and the resulting health effect. This is called the *latency period* and can be as long as 30 years for some types of cancer.

- People move around a lot and do not necessarily live in the same neighbourhood or community for many years. This makes it more difficult to establish a history of their exposure to contaminants.

However, you *may* be able to show that there are corresponding trends between factors in the environment and community health which show the need for a more detailed investigation of your community.

This Section goes on to describe the steps in preparing a community health profile. These are:

- gathering the initial information;
- collecting and summarizing existing health information;
- collecting and summarizing other relevant information;
- finding community-based knowledge; and
- preparing an evaluation.

More information about the relationship between the dose of contaminants and human health response is found in ***Part B: Background Information****.*

3.1 Gathering the Initial Information

Getting the facts straight about any health problems in the community involves clarifying and investigating any claims about specific illnesses. Initially, your investigation should focus on the following questions:

- Where do the people with the suspected health problem or illness live and work? How long have they lived or worked in this community? Add this information to a map of your community. Estimate the total number of people in your community as well as the number of known cases of the health effect or illness.
- What are the case histories of the people with the health effect or disease? This may require direct contact with them or their families. Indicate whether the problems have been confirmed by a doctor or whether they are self-reported. When did the disease or health effect first occur and what were the circumstances surrounding its occurrence? What has happened since? Try getting someone with experience in taking case histories, such as a nurse, medical practitioner or a social worker, to perform interviews and to document the information.
- Are there any obvious links between the individuals with similar diseases or health effects? For example, based on the information that you have collected,
  - Do they live or work in the same area?
  - Do they attend the same school?
  - Do they belong to the same social organization, church or other group?

  - Do they have common habits or activities such as smoking, fishing and hobbies?
  - Do they use a common source of drinking water? Are they all located downwind from a nearby smokestack?
  - Do they all live in houses with cracked foundations or leaking basements?
  - Do they all eat substantial amounts of the same type of food, for example, freshwater fish?
- How are the suspected health problems distributed in the community, for example, geographically, by age or gender?
- Are the cases of health effects or disease evenly distributed across your community or do they appear to be clustered in any area, age group or gender?

For information on designing and conducting a detailed community health survey, see ***Part B: Background Information.***

DISEASE CLUSTERS

A disease cluster may be described as an unusual aggregation of disease that occurs at a particular time and place. An example of a "cancer cluster" is the reporting of three leukemia cases occurring within two years among residents of the same neighbourhood. Virtually every disease varies in occurrence from one place or time to another. There may be many occurrences of the disease in a particular place or time, and a few or no cases of the disease in another place or time. A number of factors can be associated with a disease, such as geography, socioeconomic factors, ethnic origin and lifestyle factors; but only some associations stand up to scientific criteria.

The appearance of disease clusters within communities can focus attention on their possible causes. In recent years, much concern has been expressed about the possible connection of clusters of cancer cases to pollutants in the environment. However, health agencies which have investigated clusters have found that major associations between exposures and disease clusters are rare. In over 500 investigations of reported clusters by the Minnesota Department of Health, only six went to full-fledged studies, with only one showing positive associations between the cause and the disease.

Even though causes of disease clusters are difficult to establish, preliminary investigations of clusters are worthwhile. They serve to inform citizens and to allay their anxieties. In certain instances, the results of early investigations may point to the need to do full-fledged studies. Some past cluster investigations have led to the identification of their causes, and to measures to protect communities and to prevent diseases.

CASE STUDY

Cornwall - Air Quality Study

The Cornwall Air Quality Committee sought the help of Health Canada to investigate cancer and lung disease in the Cornwall area. Health Canada contributed staff time and expertise to do the research on the existing Canadian Institute for Health Information (CIHI) database, which was available from the Laboratory Centre for Disease Control in Ottawa. In comparison with six other Ontario cities, Cornwall had the same overall rates of cancer and lung disease as Hamilton, Sudbury and Windsor. However, the rate of hospitalization for asthma was approximately double that of other cities. An epidemiologist from the University of Ottawa, part of a multidisciplinary team investigating ecosystem health in the St. Lawrence River basin, joined the investigation at this time. Further research, recommended by this epidemiologist, showed that infants under two years of age had four times the expected provincial hospital admission rate for asthma. Lung and male rectal cancer rates were also elevated in comparison with the rest of the province.

3.2 Collecting and Summarizing Existing Health Information

The next step is to collect and summarize the existing health information available in your community. Much of this information is found in computerized databases kept by government and private agencies. Because retrieving this information can take a great deal of time, most agencies will charge you to cover their expenses, although lower costs can sometimes be negotiated. In addition, interpreting the data is very difficult. A trained statistician or epidemiologist can help you with this step.

Community Health Status Reports

Under the Ontario Ministry of Health's Mandatory Programs and Guidelines for Public Health, each public health unit is required to produce a community health status information report at least every five years. These reports can cover topics ranging from population characteristics, to lifestyle and disease, which are relevant to the health status of the community. Contact your local public health unit to obtain access to these reports.

Mortality Data

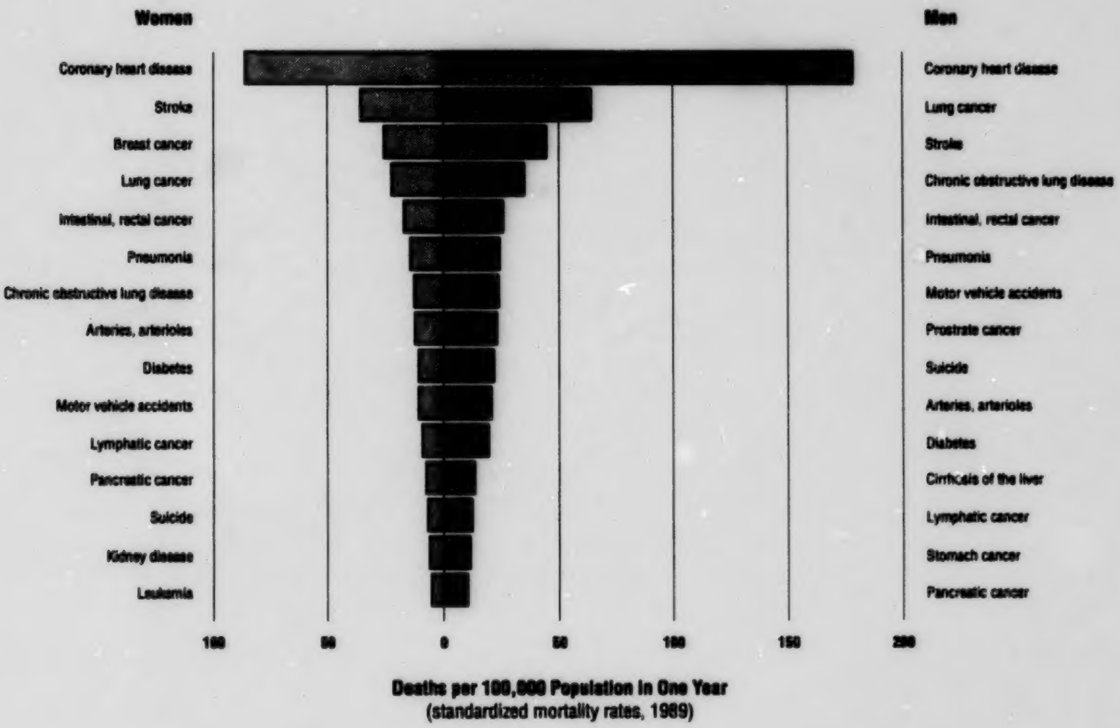
Collect data on the causes of death or mortality in your community. Mortality information for Canada is maintained by the Health Statistics Division at Statistics Canada. Before contacting Statistics Canada, be sure that you are clear about exactly what you want. For example:

Mortality data will give you a good overview of the most common causes of death in your community. However, it is very unlikely that exposure to contaminants in the environment is directly related to patterns in the causes of death.

- **What geographic area are you concerned about? Can it be defined by postal codes, municipal boundaries or census divisions?**
- **What time period are you interested in? For example, you could request mortality data for the previous five or ten years.**
- **What causes of death are you interested in? Are there causes of death particularly related to your initial concerns? Be specific. Information about mortality data is usually grouped according to cause of death.**
- **What age groups and genders are you interested in? Do you want the data displayed for different age groups and men and women?**
- **What will be your control group? To study the mortality rates in your community, it is usually necessary to compare them with another group. Do you want to compare yours to national averages, averages in the Great Lakes Basin or another community?**

FIGURE 2:

An Example of Health Data: Major Causes of Death in Canada



CASE STUDY

Cornwall - Air Quality Study

The results of the preliminary investigation on cancer and lung disease were based on unreviewed medical records. Due to the apparent high rates of hospital admission of children for asthma in the Cornwall area, the Cornwall Air Quality Committee decided to focus on determining the validity of the asthma data.

Discussions with local doctors showed that it was important to determine whether the higher admission rate for asthma was a result of extra beds being available, or of more children having asthma as a result of air pollution. Validating the data could occur in several ways: pediatricians could record the circumstances surrounding new cases of asthma admission for children, schools could be surveyed or medical records could be reviewed by medical professionals.

A multi-agency meeting revealed that a complete study would cost more than any agency could provide. The Committee accepted an offer by the local Lung Association to have its volunteers (who were medical professionals - nurses, etc.) review the asthma admission records. The Eastern Ontario Health Unit, which agreed to lead the study, sought permission from the hospital to access the records, and designed the study in collaboration with the Lung Association. The review of existing medical records then proceeded.

Some chemicals, as well as some kinds of radiation, can cause cancer in laboratory animals under specific conditions. Some of these chemicals and some forms of radiation may cause cancer in people. Substances that cause cancer are called carcinogens. The International Agency for Research on Cancer (IARC) lists over 40 chemicals known to be human carcinogens.

Cancer Incidence

The Ontario Cancer Treatment and Research Foundation (OCTRF) keeps a database of the numbers and types of cancer in Ontario. Be specific about what information you are interested in by answering the questions listed above. There are over a hundred different types of cancer and you should decide which types you want to know about. An epidemiologist or toxicologist can advise you about the types of cancer (if any) that have been associated with the substances of concern to your community.

Congenital Anomalies

A third source of information is the congenital anomalies database, maintained by the Ontario Ministry of Health in Toronto. This database contains information on abnormalities in newborn children reported by Ontario physicians. Again, be specific about what information you are interested in by answering the questions listed above.

Canadian Institute for Health Information

A fourth source of information is the Canadian Institute for Health Information (CIHI) database. This database contains information on the reasons for hospital admissions in Canada. To use this database, you must ask for information on particular causes, health effects or diseases related to your health concerns that are serious enough to cause admission to a hospital. Examples are respiratory problems including bronchitis and severe asthma attacks. It may help to work with an epidemiologist or statistician when trying to access this information.

Other sources

Other sources of existing health information on your community include:

- any health studies of the community that have been conducted previously; and
- general information from physicians or health care workers.

3.3 Collecting and Summarizing Other Relevant Information

Collect and summarize other information relevant to the health of your community. This type of information includes:

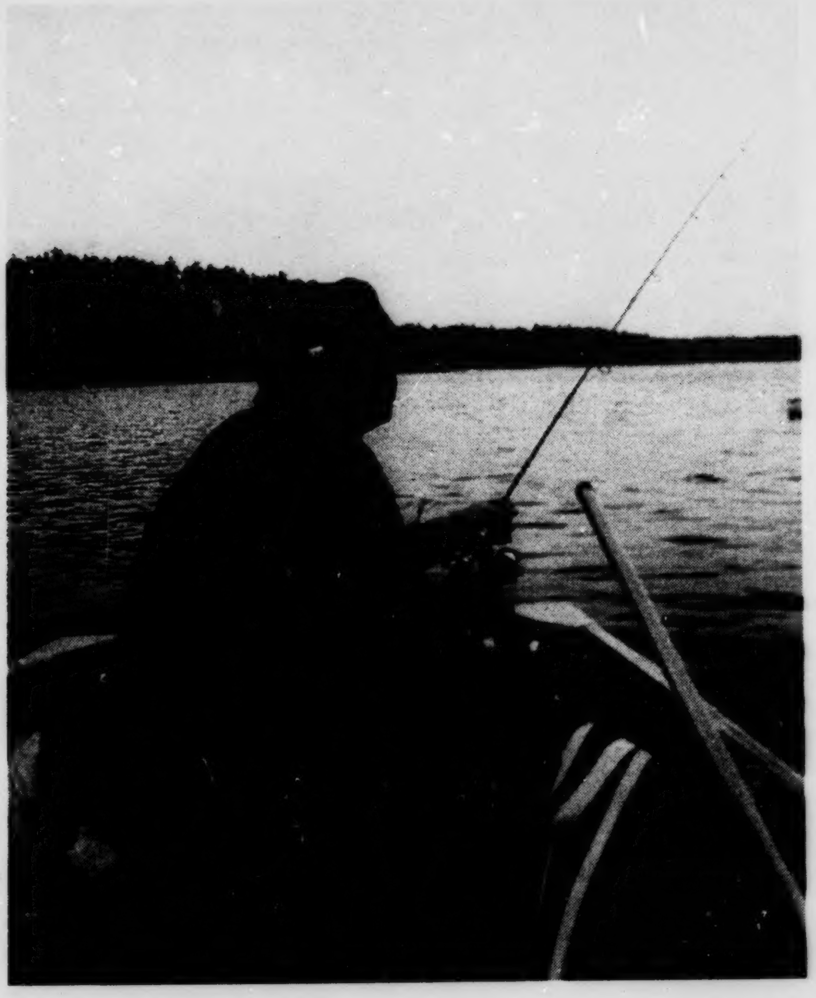
- An employment profile of your community: Where do people in your community work?
- A socioeconomic profile of your community: Socioeconomics includes items such as household size, income, education, home ownership and ethnic background;
- An age/gender profile of your community;
- A lifestyle profile of your community: What activities or behaviours are common in your community? What recreational activities do people enjoy?
- How accessible is health care in your community?

One important source of this type of information is the Canadian Census, conducted every four years by Statistics Canada. As before, be specific when you ask for information.

CASE STUDY

Cornwall - Air Quality Study

The Cornwall Air Quality Committee did not formally collect other relevant information such as employment, socioeconomic or lifestyle profiles of the community. The Committee was aware that the unemployment rate in the community was higher than the provincial rate and that the proportion of the population receiving social assistance was very large. It did not feel that further investigations would add substantially to this knowledge.



3.4 Finding Community-based Knowledge

Don't forget to talk to people in your area about health in the community. Past and present community residents are an invaluable source of information. Get as many independent accounts as possible. Older people who have lived in your community for a long time can give you a perspective on how the health status has changed over time. Talk to people living in different areas to get an idea about the health status in different parts of your community.

Health care workers have a lot of interesting information. Talk to midwives, nurses, homecare workers and physicians. Document all interviews thoroughly, so that you have a record of the information provided.

CASE STUDY

Cornwall - Air Quality Study

One of the first actions taken by the Cornwall Air Quality Committee was to host two public meetings to discuss the Committee's activities and to gauge community concerns. The response at these meetings was overwhelmingly toward health concerns. The input from the community has significantly influenced the Committee's activities, which has consequently focused on health issues.

3.5 Preparing an Evaluation

The last step in conducting a community health profile is to prepare a written evaluation. Include the following information:

- the nature of the problem or concern;
- the objectives of your survey;
- the methods and procedures used to gather the information;
- the data and information collected;
- your interpretation of the data and information;
- conclusions and recommendations; and
- a clear, concise summary for widespread distribution in the community.

CASE STUDY

Cornwall - Air Quality Study

The asthma study was in progress at the time of writing. A formal report had not yet been prepared. However, the Cornwall Air Quality Committee continued to meet regularly and report on the progress of the study. Discussions, study updates and other business were recorded in the minutes of the meetings, which were available to the public.

4. NEXT STEPS

4.1 Communicating about Your Investigation

The written evaluation will be one important step in telling others about your investigation. However, it makes sense to think about what you communicate about the study to whom, how and when - right from the beginning. Good communication is all the more important because health issues often call forth strong reactions from the general public. Developing and following a communications strategy, which takes into account the potential impact of your work, also helps you to reach your goals. Indeed, if other organizations are doing much of the research, one of the most important roles your committee can play is to ensure good communications.

Communication about the investigation begins when you start to explore whether others share your concern. It includes how committee members communicate with each other, your contacts with agencies that may provide assistance, public meetings, surveys, contacts with the news media, as well as any reports you produce. A communications strategy can focus just on the most sensitive contacts with the public and the news media, or it might cover all aspects of your communications.

Developing a Communications Strategy

The strategy may be as simple or as complicated as you desire - scale it to the level of effort in your study, the resources available to carry it out and your committee's interests. Consider your goals - whose support do you want to keep, whose do you want to win? How can your communications contribute to that support?

Questions to Consider

When to communicate?

When do you communicate, and with whom? Generally, those involved in the study - either as members of the committee or agencies providing support - should receive news first. Other people to keep informed are those who work in public positions that are central to the issue.

When should you release information to the general public? The public often perceives a high risk where a scientist sees inconclusive evidence. Even the fact that you are carrying out an investigation will suggest to some that there is a real problem. Releasing information earlier can have the advantage of increasing awareness of the issue in the community and building support for change. On the other hand, it may damage your credibility, if "experts" who are not on the committee perceive your actions as being sensationalist or if your later findings do not support what the earlier evidence seemed to suggest. Consider also any external factors such as an upcoming decision on clean-up. You may want to release information just prior to the decision to build public momentum for a clean-up. You can plan ahead for major communication events, such as a press conference, once you know more about the timeline for the investigation itself.

Who to communicate with?

Create a list of people to keep informed. For each, decide on the frequency and best vehicle for communication. Besides members of your committee, resource people who work with you and the general public, consider the list, found in **Section 1.2 Organizing the Work,** of people who may be interested in the study.

How to communicate?

Communication can take many different forms:

- Committee meeting minutes are a good way to keep both committee members and others supporting the study up to date.
- Personal conversations are an excellent tool to build support with outside agencies, politicians, etc., especially when the contact people remain the same over a period of time and can build the trust that comes from a personal relationship.
- Thank you gestures for assistance received are not only appreciated personally, but the recognition can help an agency to justify providing more assistance.
- Written material, such as a newsletter or a brochure describing your investigation, can be suitable for those who need less information than is in your minutes.
- Public meetings are a good way to reach the concerned public.
- Presentations to committees or the staff of an organization can be informal ways of engaging in a discussion with potential supporters.

Think about matching the form, content and style of your communication with your audience. Politicians and the general public will respond better to shorter, less technical communications than would be appropriate for health professionals or scientists.

What about the news media?

The news media allow you to reach a much wider audience. However, there are usually more stories than the space or time available. Less interesting stories get crowded out. Community newspapers and cable TV generally have more space for local stories. They may even accept a story or program that your committee writes or creates.

Making a story interesting for the media is an art. Inconclusive study results or a discussion of concerns of which the community is already aware do not make particularly good stories. Sometimes, presenting the story differently to give it an interesting slant helps, or creating an event, such as the launch of your investigation. Public meetings or presentations to public bodies, such as a municipal council, can also become media events. You should be aware, however, that media presence often changes the way people participate at meetings. Because the media are not health experts, it is important to decide what your central message is and interpret results in a manner that is quickly understood.

The science behind health and environment stories is often complex, and you may find your message comes across most accurately by working consistently with the same one or two reporters. They may already have some background understanding of the issue, or you may have to take the time to educate them and provide friendly feedback on stories about your investigation. Letting them know that they are the only ones who have the story helps to get your story published.

Useful media tools include:

- News releases are a news story listing a contact person, written in a catchy newspaper style and sent to the newspapers, radio and TV stations.
- Media interviews can result from a news release or other action on your part. Decide what your main point(s) is and use every question to repeat it. Remember that everything you say, even if you meant it to be "off the record" can appear in public.
- A press conference is a presentation to a group of journalists, followed by a question and answer session. It can be used to announce a significant new initiative or to present the findings of your investigation.
- A local cable TV show may be an opportunity for you to create a show focused on the investigation.

What to communicate?

Situations may arise where you are in possession of sensitive or confidential information. To ensure that confidentiality is not breached, consider developing procedures on handling such information among committee members. It may be useful to appoint a spokesperson who will ensure that communication is consistent with your strategy and with decisions about what is public and what is not. Consult with committee members and any agency partners before releasing any sensitive information.

Do you want feedback?

Communication has more than one direction. Consider where information and responses would be useful to you and create channels for receiving it and dealing with it. It may be as simple as listing a contact name and phone number on information you provide. Public meetings, response forms with questions you want answered and surveys can also provide useful information.

Do you need help?

Communicating well is an art. Some people have made it their profession. You may want to draw on their skills for advice or encourage them to join the committee and help to develop and implement your strategy. People to consider are community leaders, people who work in marketing, the news media, public relations or public consultation, and the communications staff of local public health units or other public agencies.

4.2 Pursuing Your Recommendations

If, in the estimation of the committee and contributors to the research, your investigations support the initial concerns, in terms of either exposure or health effects, it is likely that a quantitative exposure assessment and/or a comprehensive health study will be recommended. If this is the case, these types of studies can be performed by experienced organizations with specialized knowledge on design and interpretation of population studies. The process followed in carrying out community health studies is briefly described in **Part B: Background Information**. These detailed assessments can lead to the development and evaluation of options to reduce exposure to contaminants, remediate (i.e., clean up) their sources or to address the health issues being investigated in the community. With more information, communities can make informed decisions for choosing and implementing these options.

Be prepared to pursue your recommendations. Even if an agency takes on the study, you will need to follow its development to ensure that it addresses the initial concerns of your committee. Ideally, your committee will be a partner in the study development and process.

Even if your studies do not suggest anything out of the ordinary, your committee could consider using its expertise and resource people to establish a local environmental committee. Many municipalities are now forming such committees, usually comprising volunteers who are concerned about the environment and have some relevant knowledge. Their role is to provide advice to municipal Councils or sub-committees of Council on relevant environmental matters. They can also serve as an environmental advocate or "watchdog."

CASE STUDY

Sault Ste. Marie - St. Marys River Study

At the outset, the uncertainty over the risks to health posed by exposure to PAHs from swimming in the St. Marys River had led to a high level of concern in the community. The study showed that swimming at beach sites posed little risk to health and public concern over the PAHs in river sediments was reduced.

The results of the study helped to rank areas of the river for clean-up priority. It prompted the local steel mill to clean up the sediments in its slip, which was the most contaminated spot on the river.

Cornwall - Air Quality Study

The asthma study was in progress at the time of writing. However, the Cornwall Air Quality Committee has since obtained administrative and organizational support from the St. Lawrence River Institute of Environmental Sciences. The Committee was also initiating discussions on investigating the incidence of certain cancers in the area.

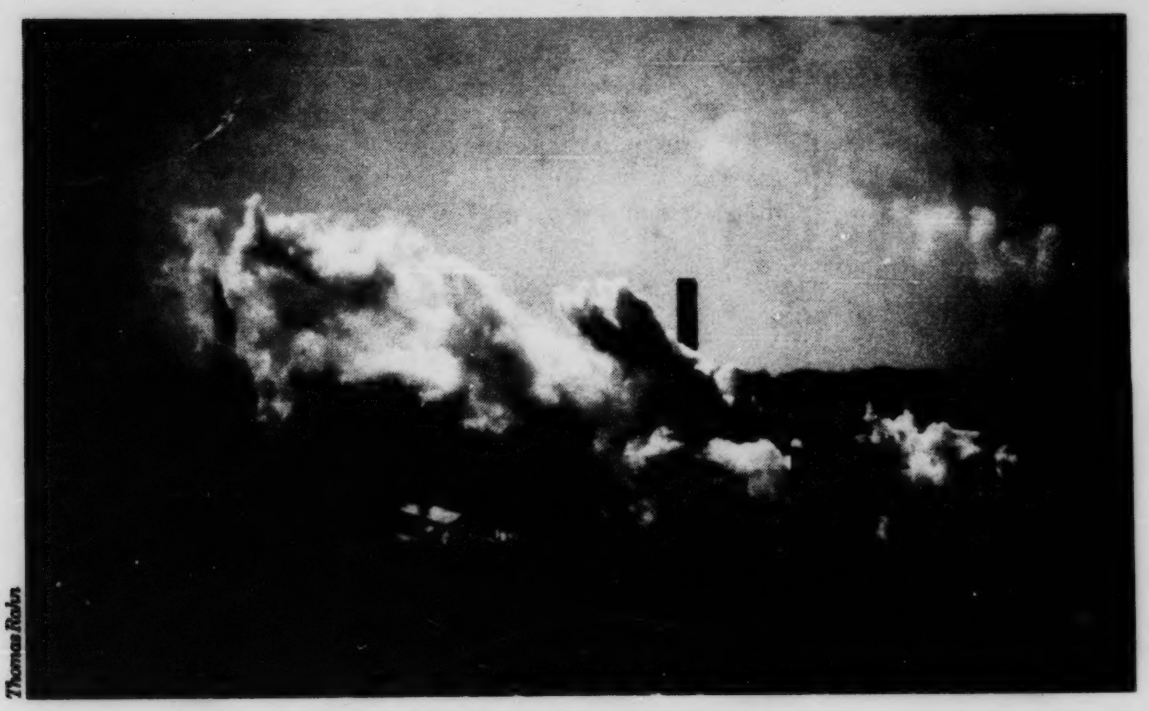
Investigating Human Exposure to
Contaminants in the Environment:

A Community Handbook

PART B: BACKGROUND INFORMATION

This part of the handbook contains basic information about contaminants in the environment and some of their potential health effects. Specifically, it describes:

- the major types of contaminants in the environment;
- how people can be exposed to them;
- the scientific approaches that are commonly used to investigate the relationships between exposure and health effects; and
- some of the health effects that have been associated with exposure to some contaminants.



Thomas Rahn

1. MAJOR TYPES OF CONTAMINANTS

Contaminants in the environment can be categorized into four major types. These are:

- chemicals, including organic and inorganic ones;
- microorganisms, including bacteria, viruses, fungi and protozoa;
- radiation, including ionizing and non-ionizing types; and
- physical hazards, especially dust (also called particulate matter).

These are described in more detail below.

1.1 Chemicals

There are two basic types of chemicals in the environment; organic and inorganic. Organic chemicals are composed of carbon, usually in combination with other elements such as hydrogen, oxygen or chlorine. Inorganic chemicals include metallic elements such as lead and cadmium, as well as non-metallic ones, such as silica and nitrogen. The building blocks for all chemicals come from the earth. All life depends on chemicals. However, through industrial activities, living organisms, including humans, have come to be exposed to a large number of chemicals which have not been a part of their environment in the past. These "new" chemicals were either substances that were buried in the ground or chemicals created by industrial production, either deliberately or as a by-product.

Since the Second World War, there has been an enormous increase in the amount and number of chemicals manufactured, used and disposed. While there are beneficial uses for most chemicals, by-products from manufacturing and wastes can cause problems in the environment, as can chemicals that are not treated or handled properly.

Manufactured chemicals are a part of all aspects of modern life. Some of their uses are:

- as pesticides and fertilizers;
- to preserve or colour food and to enhance food flavours;
- in drugs and cosmetics;
- in many different manufacturing industries;
- in paints, varnishes and glues; and
- as disinfectants and cleaning agents.

In recent years, there has been a lot of concern about the levels of persistent toxic chemicals in the Great Lakes Basin. Concern has focused on some organochlorine chemicals. These are chemicals that contain carbon, hydrogen, sometimes oxygen, and chlorine. The persistent toxic organochlorine chemicals of concern can include:

- PCBs - now banned, used in electrical transformers, hydraulic equipment and lubricants;
- dioxins and furans - now restricted, by-products of pesticide manufacturing, waste incineration and pulp and paper manufacturing;
- DDT and the substances it breaks down into (its metabolites) - a pesticide, now banned, that affects wildlife health; and
- aldrin, dieldrin, chlordane, endrin, etc. - other pesticides whose use is now banned or restricted.

Although the manufacture and use of most of these chemicals has been greatly reduced, they remain a health concern because those that were used in the past have not broken down and remain in the environment.

Metals of concern can include:

- mercury - naturally occurring and from industrial sources;
- lead - from industrial sources and once used in leaded gasoline; and
- cadmium - used in a variety of industrial processes.

These metals cannot break down. The only way that their hazard can be reduced is when they move to a part of the environment where they are not available to living organisms.

1.2 Microorganisms

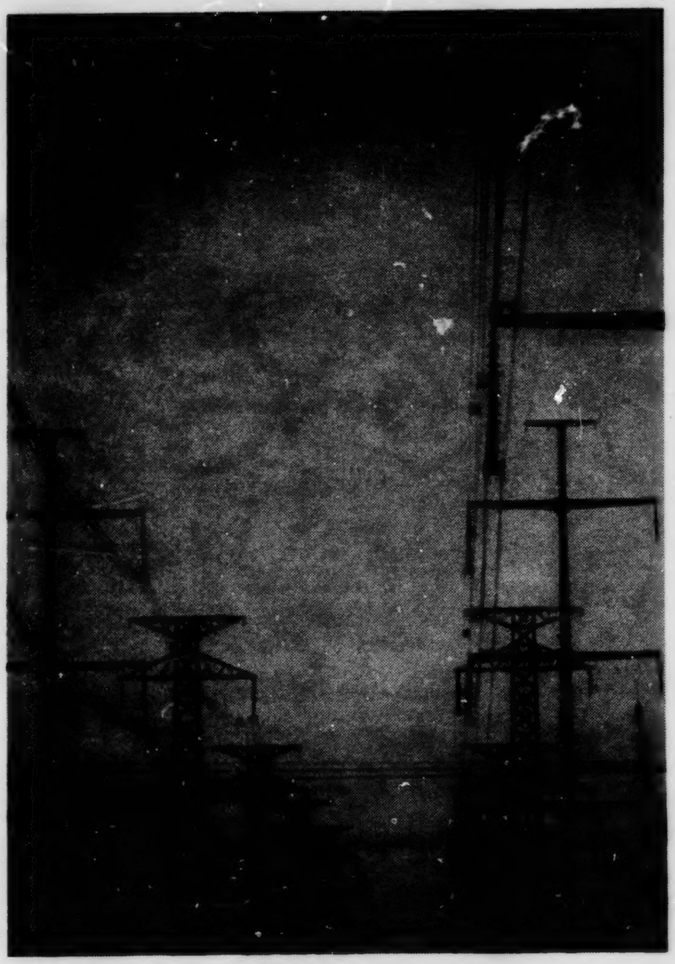
Microorganisms exist in air, water, soil, food and in and on our bodies. These microscopic organisms include bacteria, viruses, fungi and protozoa. While most of these organisms are harmless and many are beneficial, some do cause discomfort or illness in humans, ranging from allergies to infections. On rare occasions, they can cause death.

Bacteria are small, single-cell organisms that require nutrients to survive, produce waste products and reproduce by dividing in half. They often grow best when there is an abundance of nutrients and warm temperatures. Bacteria are frequently found in raw foods, such as meats, poultry, eggs and unpasteurized milk, and in water, humidifiers, air conditioners and air ventilation systems. Bacteria can cause many health problems, including infections, food poisoning and upset digestion. *Salmonella*, *Campylobacter*, *Escherichia coli* (*E. coli*), *Staphylococcus*, *Streptococcus*, *Clostridium* and *Shigella* are common types of bacteria that cause illness in people.

Viruses are microscopic organisms that consist of genetic material (DNA or RNA) wrapped in a protein coat. Unlike bacteria, they can only reproduce inside the living cells of another living organism. Often, the reproduction of a virus within a host cell will lead to the death of that cell. Many viruses cause diseases, including the common cold, measles, polio and viral hepatitis. Some viruses can contaminate drinking water if it is not properly protected and treated. For example, Norwalk viruses in contaminated drinking water can cause diarrhea in humans. Some viruses implicated in food-borne illness include Poliovirus, Hepatitis A virus, Coxsackie group A viruses and Echovirus.

Fungi are a group of widespread, unicellular and multicellular organisms that need warm, moist conditions in which to grow. Many of the products of fungi - spores, mycotoxins and volatile chemicals - can be harmful to human health. Spores can cause allergies, lung disease or diminish the response of the immune system in some people. Mycotoxins and the volatile compounds produced by fungi can cause lung and other respiratory problems. Certain varieties of mushrooms, which are a type of fungi, are toxic when eaten and can cause severe illness or death. Other fungi can grow in the lungs (Aspergillus spp. in granary and aviary workers) or on the skin (the most common in humans is athlete's foot).

Protozoa are one-celled parasitic organisms, mostly free-living in water or soil. The most common types of parasites to infect drinking water are *Giardia lamblia* and *Cryptosporidium spp. Giardia lamblia* causes giardiasis, also known as "beaver fever," and is characterized by diarrhea, loss of appetite, dehydration, cramps and in some cases, vomiting. *Giardia* may enter the water supply from human or animal waste. *Cryptosporidium* and *Entamoeba histolytica*, which is another important protozoan parasite known to be transmitted by food, also cause enteritis or dysentery.



1.3 Radiation

Radiation is a form of energy that can be classified as either ionizing (high energy) or non-ionizing (low energy). Ionizing radiation is normally referred to as radioactivity whereas non-ionizing radiations are associated with optical radiation, such as ultraviolet and visible light and electromagnetic fields, such as microwave and radio frequency. In general, non-ionizing radiation is less harmful than ionizing radiation.

Ionizing radiation is found everywhere in the environment as a result of cosmic radiation produced in outer space and radioactive nuclides in the earth. Most nuclides in nature are stable, maintaining their form and composition indefinitely, but many others are unstable. Unstable nuclides (*radionuclides*) return to stability by spontaneous disintegration (*radioactive decay*), thus forming different nuclides by releasing energy (i.e., radiation) in the form of an alpha particle or a beta particle. The new nuclide formed may still be radioactive and emit further alpha or beta radiation, or it may be in an excited state and return to stability by emitting gamma radiation. The radiation released by the decay of radionuclides, as well as the cosmic radiation from outer space, is referred to as *ionizing radiation* because it is capable of producing electrical charge in the matter through which it passes. If ionization occurs in living tissue, it can lead to biological damage.

Radionuclides are found in the environment as naturally occurring elements in the earth's crust and as products or by-products of nuclear technologies. The biological consequences of ionizing radiation exposure are the same regardless of the origin of the radionuclide. By far, the greatest contribution to the average public radiation exposure is from naturally occurring radionuclides.

Ultraviolet radiation is part of the sunlight spectrum and is invisible to the naked eye. It can be divided into three regions according to wavelength. UVC radiation (wavelength 200 - 280 nanometres - nm) has the highest energy and is potentially the most destructive ultraviolet radiation. However, it is all filtered by the ozone layer in the upper atmosphere. UVB radiation (wavelength 280 - 315 nm) is thought to be responsible for most of the adverse effects of sun exposure and is most affected by the concentration of the ozone layer. UVA radiation (wavelength 315 - 400 nm) has the least energy and is not absorbed by the ozone layer so that it easily reaches the earth's surface. UVA can enhance the effects of UVB.

Electromagnetic fields (EMFs) are associated with all electrical power and consist of two kinds of fields, electric and magnetic fields. Electric fields result from the strength (voltage) of the charge. A high-voltage power line usually produces stronger electric fields than a low-voltage power line. An electric field can exist even if a current is not flowing in an object, as long as it is plugged in. For example, an electric blanket that is plugged in, but not operating, may still produce an electric field. Magnetic fields result from the motion (current) of the charge. Since magnetic fields are created only when current is flowing, appliances that are plugged in, but turned off, do not produce magnetic fields.

1.4 Particulate Matter (Dust)

Particulate matter refers to a wide variety of minute particles and fibres carried along in the air. While there have always been particles in the air, in the form of dust, pollen, ash and smoke, in more recent times industrial activity has added to the measured levels of particulate matter. These particles vary in size, shape and chemical composition. From the perspective of human health, size may be the most significant of the three, because the smaller the particle, the greater the chance for penetration into the lungs. Particle size is measured in microns (or micrometres), one of which equals one millionth of a metre. Particles larger than about 10 microns are large enough to settle to a nearby surface after being emitted from a source. Anything smaller can remain suspended in the air for long periods and they constitute what is called "suspended particulate matter."

2. SOURCES, MOVEMENT AND PERSISTENCE

2.1 Chemicals

Sources of Chemicals

Chemicals can enter the environment in many different ways. "Point" sources of chemicals can include:

- industrial discharges;
- waste incinerators;
- sewage treatment plants;
- waste disposal sites.

"Non-point" sources of chemicals can include:

- runoff from land that has been treated with pesticides, fertilizers or herbicides;
- car exhausts;
- contaminated sediments;
- stormwater runoff from built-up areas; and
- atmospheric deposition, which is the transfer of contaminants out of the atmosphere onto the land and into the water. Often these contaminants have travelled long distances and reacted with other chemicals in the air. An example is acid rain.

For example, in Ontario there are about 300 industrial sites that discharge directly into rivers and lakes, and there are another 12,000 that dump their wastes into municipal sewage systems that cannot adequately treat toxic chemicals. Non-point sources are also important. For example, more than 90% of the PCBs, DDT and lead in Lake Superior come from atmospheric deposition.

There are natural sources of contaminants as well as human sources. For example, cadmium and mercury can be released into the environment from soil and rock by erosion due to wind and rain. Natural events, such as forest fires, floods and volcanoes, can also release contaminants into the environment.

Movement of Chemicals in the Environment

Once released, toxic chemicals can be found in different parts of the environment, including air, water, soil and living organisms. They are often "mobile" and can move from one part of the environment to another. For example, a chemical in water may evaporate into the air and then be condensed into rain and be deposited onto soil and vegetation. The contaminated plants could then be eaten by different species of animals.

As well as moving through different parts of the environment, chemicals can be carried long distances by wind and water currents and by organisms that have absorbed them. For example, the tissues of wildlife in the Canadian arctic contain traces of PCBs and pesticides that come from the industrial countries of Europe, Asia and America. Although the concentrations found in the arctic are lower than those in such areas as the Great Lakes Basin, it is clear that there is no way of avoiding exposure completely.

Persistence in the Environment

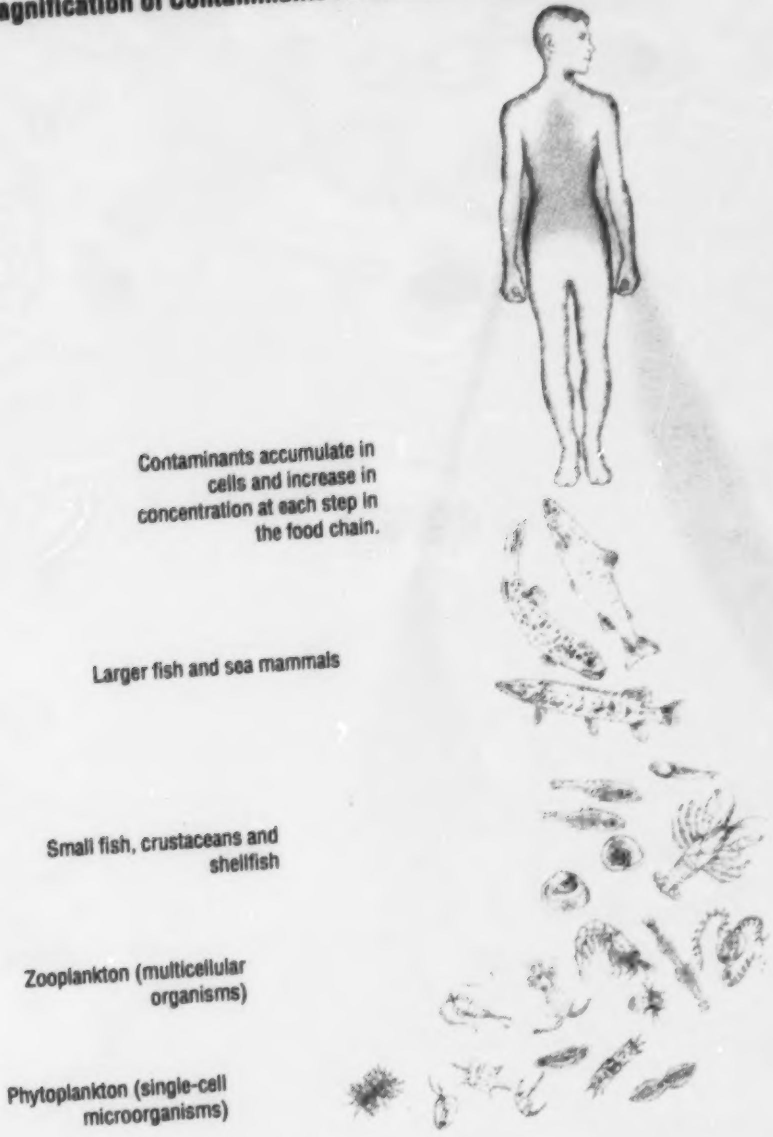
Many chemicals, such as PCBs, are quite stable in the environment and this allows them to persist for long periods without breaking down.

When absorbed or eaten by living organisms, some chemicals gradually accumulate in their tissues. Organochlorines, for example, tend to accumulate in fat because they can be dissolved in fat. Through this process - called bioaccumulation - contaminant levels in living organisms can build up to harmful levels. Organisms can also pass on their accumulated load of contaminants onto other animals that feed on them. This is known as biomagnification. As a result, concentrations of some contaminants get increasingly higher as one goes up the food chain. Biomagnification is shown in FIGURE 3.

Thomas Rahn

FIGURE 3:

Biomagnification of Contaminants in the Food Chain


Contaminants accumulate in cells and increase in concentration at each step in the food chain.
Larger fish and sea mammals
Small fish, crustaceans and shellfish
Zooplankton (multicellular organisms)
Phytoplankton (single-cell microorganisms)

Biomagnification

A persistent contaminant present at very low concentrations in water can bioaccumulate in plankton or small fish. When a larger organism, such as a fish, eats many of these small creatures over its lifetime, it in turn bioaccumulates the contaminants already bioaccumulated in its food, and the contaminant becomes even more concentrated. At each level of the food chain, the concentration increases or "biomagnifies." The accumulated level of persistent trace chemicals in fish or other animals high in the food chain can pose a significant risk to health.

2.2 Microorganisms

Sources of Microorganisms

Those microorganisms in the environment which affect human health have several important sources. These include contaminated or poorly prepared food, untreated or partially treated waste water and other rotting or decaying biological wastes such as animal and human wastes and carcasses.

Movement of Microorganisms in the Environment

Bacteria, protozoa, viruses and fungi can be carried quite long distances by other organisms or by water or wind currents. For example, migrating birds can carry bacteria and viruses many thousands of kilometres in or on their bodies.

Persistence in the Environment

Unlike many chemicals, microorganisms are often not very persistent in the environment, and will die out unless they can reproduce. However, some microorganisms can form "spores" which are extremely resistant to environmental change and are very persistent. Mycotoxins produced by moulds are persistent substances and may remain in a product even after the moulds that produced them are killed. The cysts formed by the protozoans *Giardia lamblia*, *Entamoeba histolytica* and *Cryptosporidium* spp. may persist for long periods in natural waters.

2.3 Radiation

Sources of Radiation

The major sources of ionizing radiation are natural. We are all exposed to ionizing radiation from space (i.e., cosmic), as well as from the earth itself (e.g., uranium, radium, potassium-40). Atmospheric nuclear weapons tests have contributed most of the artificial radioactivity released to the environment to date. Radiation from all aspects of nuclear power including uranium mining, processing and final disposal of the fuel, though very low, is becoming increasingly important. The products of nuclear energy are also used in medicine (e.g., radiotherapy of cancers) and in consumer products (e.g., smoke detectors). In addition to benefiting society, these applications release radioactivity into the environment, thus adding to the existing levels of radiation from natural sources.

We are also exposed to different kinds of non-ionizing radiation from many sources. Examples are:

- ultra-violet (UV) radiation from the sun, from UV lamps in tanning salons and spas, from germicidal lamps, from ultraviolet lasers, from certain kinds of industrial processes and UV radiation given off by welding arcs; and
- electromagnetic fields (EMFs) through use of electrical appliances such as hair dryers, can openers, vacuum cleaners, electric shavers, electric blankets, computers, other electrical devices (e.g., lighting) and proximity to electric power lines.

Movement of Radiation in the Environment

Radiation is unique among the contaminants discussed in this handbook in that it is capable of penetrating or travelling through matter. Just as non-ionizing radiation such as light, heat or microwaves are transmitted through the air, so too is ionizing radiation. However, because ionizing radiation is generally more energetic than the other forms of radiation, it can also penetrate matter. The degree to which ionizing radiation can penetrate matter depends on both the material and the type of radiation. For example, alpha radiation can be stopped by a piece of paper or the outer layer of the skin on the body, whereas several inches of lead are required to stop gamma radiation.

Radionuclides, or radioactive material, can be released into the environment as a gas, liquid or particle. Material released into the atmosphere is transported and dispersed by wind currents and may be removed by rain or settle as dust. The deposited radionuclides may also accumulate in soil or be leached into groundwater, which may lead to the contamination of well and surface water. Radionuclides may also enter and move through the food chain. Some of these processes result in progressive dilution, others lead to concentration in the environment.

Persistence in the Environment

Radiation can be generated continuously by natural and artificial sources. In some cases, the half-life (the time required for a material to lose one half of its radiation) of some radionuclides is very long. However, the persistence of a radionuclide in an environmental medium, such as water, is often much less than its radioactive half-life due to environmental and biological processes which lead to their progressive dilution.

The sun continuously emits ultraviolet radiation, much of which is absorbed by the Earth's ozone layer, which is situated between 15 and 35 kilometres above ground level. Electromagnetic fields are being generated continuously as long as electricity is being transmitted through a line. They are strongest close to the source and rapidly decrease in strength as one moves away from the source.

2.4 Particulate Matter (Dust)

Sources of Particulate Matter

The principal sources of particulate matter released into the air, as a result of human activity, are:

- industrial processes;
- fuel combustion;
- transportation; and
- solid wastes.

Industrial operations, such as power stations, solid waste incinerators, smelters, mills, refineries and factories, can release very fine particles containing a wide range of compounds into the air. Particulates can contain such compounds as acid mist, arsenic, asbestos, beryllium, cadmium, lime, mercury and silica.

The principal sources of particulate matter released into the air, from naturally occurring events, are:

- volcanoes;
- wind erosion;
- forest fires; and
- pollens from plants.

Movement of Particulate Matter

Particulate matter is dispersed in the air and can be carried long distances by the wind. Particles can be deposited on soil and plants where some contaminants can be taken up by the plants. They can be deposited on water where the contaminants can enter the food chain. For example, even though DDT has been banned in North America for several years, it is still used elsewhere in the hemisphere, and may be entering the Great Lakes through long-range atmospheric transportation and deposition.

Persistence in the Environment

Particulate matter eventually settles out of the air and is deposited on a surface. In itself, a particle may not be persistent, but contaminants adsorbed on the particle may be persistent. Therefore, the origin and composition of the particle will determine its persistence.

3. EXPOSURE

Exposure is any contact between a substance and an individual who has touched, breathed dust or fumes, or swallowed material or liquid from a contaminated source. Contaminants must follow pathways from the point of release into the environment to the point of contact with humans in order for exposure to take place.

Exposure Pathways

An **exposure pathway** describes how a contaminant travels through the environment from its source to humans or other living organisms. An exposure pathway consists of the five following elements:

- source of contamination;
- environmental media;
- point of exposure;
- receptor person or population; and
- route of exposure.

Source of Contamination

Sources of environmental contaminants are numerous. They include exhaust from vehicles, emissions from smokestacks, wastewater released by factories and mills, waste disposal sites, closed factories and storage sites, consumer products (e.g., paints, household cleaning products) and numerous other sources, both indoors and outdoors. A number of substances are also released into the environment from natural sources.

Environmental Media

Once released from its source, a contaminant will travel through environmental media to points where human exposure can occur. For human exposure, the major environmental media include water, air, food and soil.

Water

- drinking water, whether from a surface water source (e.g., a lake or river) or a groundwater source (e.g., a municipal or private well);
- recreational use, such as swimming, boating, windsurfing; and
- industrial or agricultural use.

Water is an important exposure pathway for chemicals and microorganisms.

Air

- indoor air, including air quality at home, work and school; and
- outdoor air.

Both indoor and outdoor air are important environmental media for exposure to a variety of contaminants, including microorganisms. In many instances, some contaminants may be more concentrated indoors than outdoors.

Food

- foods grown with contaminated water or grown in areas where the soil is contaminated. This would include food grown for personal consumption;
- contaminated fish and wildlife;
- foods containing pesticide residues;
- foods packaged in containers which contaminate the contents (e.g., lead-soldered cans used in some imported goods); and
- mother's milk (for nursing infants), where the mother has been exposed to chemicals which accumulate in fat in tissues (breast milk has a high fat content).

Food can be an important medium for exposure to many environmental contaminants, including microorganisms.

Soil

- bare ground (exposure of workers to soil, swallowing soil or skin contact with soil);
- contaminated soil blown as dust in the air and particles deposited on other surfaces (such as food);
- soil below the surface (workers involved in digging and excavating); and
- contaminated sediments at the bottom of lakes, rivers and ponds.

Soil is an important exposure pathway for small children who often put contaminated objects in their mouths. Contaminants can settle and accumulate in sediments where people can become exposed while playing and swimming. Exposure to chemicals and microorganisms can occur through soil and sediments.

Point of Exposure

The point of exposure is the location where contact with a contaminant occurs. For example, people can be exposed to contaminants in the home, a business, a playground, a lake, river or other body of water.

Receptor Person or Population

The receptor person or population is the one exposed to the contaminant at the point of exposure. For example, swimmers may be exposed while bathing in a contaminated river; anglers may be exposed by consuming contaminated sport-caught fish.

Thomas Rahn

Routes of Exposure

People can be exposed to contaminants in water, air, food and soil in several different ways. The exposure route is the final link in the chain from the contaminant source through the exposure pathway to human beings. The exposure route describes how the contaminant enters the body. The three main routes are:

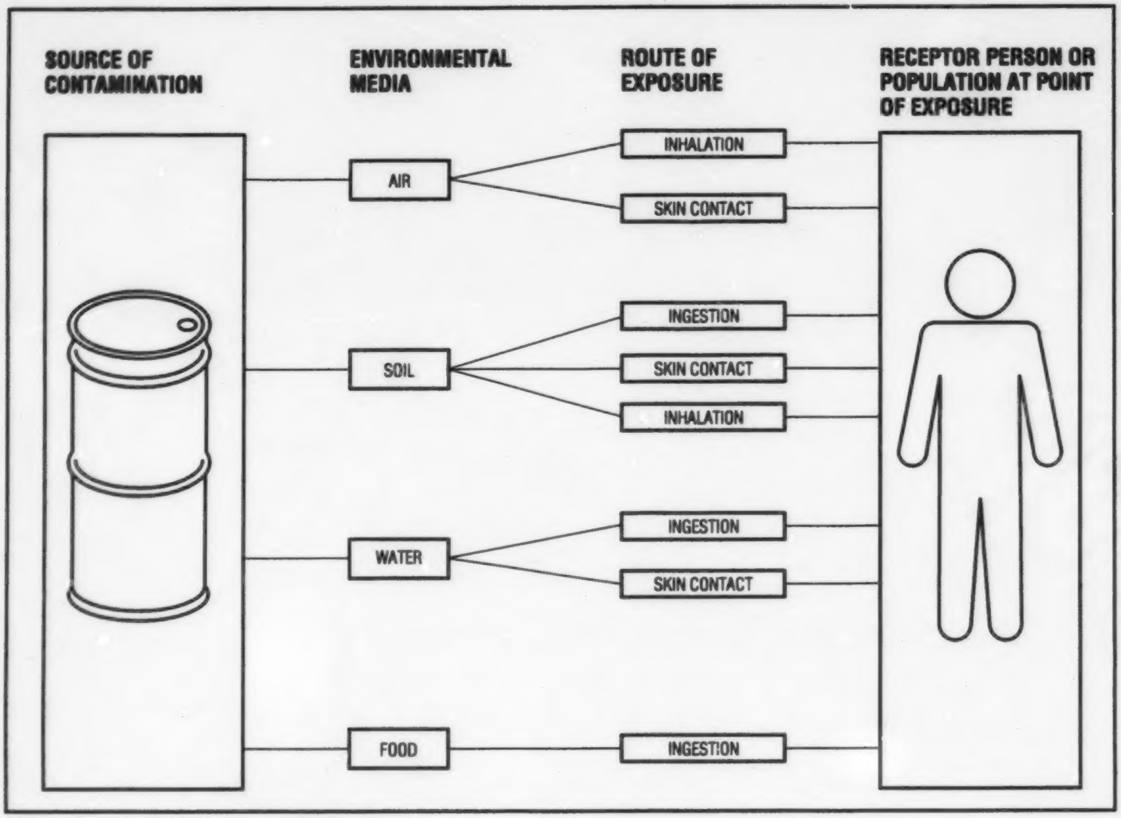
- ***Ingestion*** - Swallowing food, water, small amounts of soil and accidental ingestion of objects or other liquids containing the contaminant. The mouth, throat, stomach and intestines can absorb ingested materials rapidly and at different rates, depending on the material.
- ***Inhalation*** - Breathing in a contaminant such as a gas, vapour or airborne particles. This includes small amounts of soil and dust that can be inhaled into the lungs. The lungs often absorb gases and vapours quickly and efficiently.
- ***Skin Contact*** - Some contaminants in water, soil or air can be absorbed through the skin. The skin is usually an efficient barrier to most contaminants. In the case of radioactivity, exposure can occur through penetration of the skin by radioactivity in the atmosphere or released from radionuclides that are in the air or on the ground. The radionuclide does not actually need to be in contact with the skin.

The major pathways of human exposure to environmental contaminants are shown in FIGURE 4. Food ingestion is the major exposure pathway for many persistent chemicals such as DDT, PCBs and some metals such as mercury, with air, water and soil products contributing only small amounts to the total human exposure. Based strictly on environmental contaminants, ingestion of untreated drinking water is the most important exposure pathway for microorganisms. However, due to improper storage and handling, food is an important pathway for exposure to microorganisms causing illness.

For exposure to radiation, there does not have to be physical contact with a radioactive substance, because radiation can travel through matter. Exposure can occur through penetration of the skin by radioactivity in the atmosphere or released from radionuclides that are in the air or the ground.

FIGURE 4:

Major Pathways of Human Exposure to Environmental Contaminants


SOURCE OF CONTAMINATION
ENVIRONMENTAL MEDIA
ROUTE OF EXPOSURE
RECEPTOR PERSON OR POPULATION AT POINT OF EXPOSURE
AIR
INHALATION
SKIN CONTACT
SOIL
INGESTION
SKIN CONTACT
INHALATION
WATER
INGESTION
SKIN CONTACT
FOOD
INGESTION

Exposure to ionizing radiation from radionuclides in environmental media may also occur by direct external irradiation.

It is important to remember that exposure to contaminants does not always result in their absorption into the body. The lungs, digestive system and especially the skin can present very effective barriers to many substances. For instance, inhaled substances can be swept out of the lungs and expelled. Absorption of chemicals may vary depending on the route of exposure. For example, a substance that is readily absorbed through the respiratory tract may not be as readily absorbed through the gastrointestinal tract or skin, and vice versa. The absorption of a chemical will also be affected by its chemical and physical properties. In general, the more a chemical is soluble in fat, the more easily it will be absorbed into the body.

Substances that are absorbed can be transported throughout the body by the bloodstream. Once in the body, these substances can be either broken down into other substances, stored in the body or excreted. In many cases, the liver breaks the substance down, so that it can be excreted as waste material through the bile, urine or feces. When the intake exceeds excretion, build-up of these substances in the body can occur.

Many contaminants, such as microorganisms, are not absorbed into the bloodstream but can cause adverse health effects where they contact the body. For example, drinking water contaminated with microorganisms can cause diarrhea, nausea and cramps; detergents and dust can cause dermatitis where they contact the skin. Radionuclides do not need to be in contact with the body to cause their effects since the radiation emitted can travel through matter to result in an exposure.

Estimated Daily Intake for Exposure to Chemical Contaminants

People are exposed to low levels of chemical contamination in the air they breathe, in the food they eat and in the water they drink. In detailed exposure assessments, this exposure is quantified and called the Estimated Daily Intake (EDI). A separate EDI is calculated for each contaminant of concern. The EDI is the sum of exposures from all known or suspected exposure pathways for an average person. Numerous other factors must be considered, making these types of estimates complex - especially because assumptions are used that require a great deal of professional judgement. The information in the box below gives a basic overview of the type of calculations involved.

CALCULATING THE ESTIMATED DAILY INTAKE

Estimated Daily Intake (EDI) of a chemical can be calculated by adding up all the exposures from various pathways. The EDI of one contaminant can be represented by the following equation:

$$EDI = ED_a + ED_w + ED_s + ED_f + ED_{ws} + ED_{ss}$$

Each ED (Estimated Dose) is the amount of the contaminant taken in through a different combination of exposure pathway and exposure route. Specifically:

ED_a is the amount inhaled through the air,
ED_w is the amount taken in by drinking water,
ED_s is the amount taken in by eating soil,
ED_f is the amount taken in with food,
ED_{ws} is the amount absorbed through skin contact with water,
ED_{ss} is the amount absorbed through skin contact with the soil.

To calculate the estimated amount of the contaminant taken in through these combinations of exposure pathway and route requires a different equation for each combination. However, all the equations are somewhat similar. The general equation for each estimated dose is:

$$ED = \frac{C \times CR \times EF}{BW}$$

where,

ED = Estimated Dose is generally the number of milligrams of the contaminant that enter the body for each kilogram of body weight (mg / kg / day).

C = Concentration of the contaminant in the exposure pathway being considered.

CR = Contact Rate: The amount of water, food, air, etc., which is swallowed, inhaled or comes into contact with the skin in one day. Typical units for food eaten are grams per day (g / day).

EF = Exposure Factor: This number indicates how often the individual is exposed during a year and the number of years that this pattern has been repeating itself. This factor is needed especially when exposure does not occur daily, such as exposures at work (only five days a week) or exposures related to seasonal activities (swimming in the summer in contaminated water).

BW = Body Weight: The average body weight of an individual in kilograms (kg).

Estimated Dose for Exposure to Ionizing Radiation

Exposure to ionizing radiation is treated somewhat differently than exposure to chemical contaminants. Because the effects of radiation exposure are well understood, radiation experts express exposure in a unit called the sievert (*Sv*), which is a measure of the total harm that may be caused in a human exposed to ionizing radiation from any radiation source. Unlike chemical contaminants, it is the total exposure from all sources that is controlled, rather than the exposure from individual radionuclides. This is done since it is the total exposure that determines the risk of a health effect occurring.

Furthermore, the dose rate is expressed on a yearly basis, rather than a daily basis. This dose is calculated to include all direct **external** irradiation received in the year, and the dose that will continue to be received **internally** from all radionuclides ingested or inhaled in the current year. The period over which this extended dose, due to internal radiation, is calculated has been standardised to 50 years for exposures in adults (18 years of age and older) and 70 years for exposures in children (under 18 years of age). Unlike the approach taken for chemical contaminants, this approach accounts for the radiation dose that will continue to be received from radionuclides that are retained in the body.

CALCULATING THE ESTIMATED DOSE FOR EXPOSURE TO IONIZING RADIATION

The Estimated Dose (ED) for exposure to ionizing radiation can be calculated by adding up all exposures received in a year from various pathways and can be represented by the following equation:

$$\begin{aligned} ED &= ED_{external} + ED_{internal} \\ &= ED_{external} + ED_{a} + ED_{w} + ED_{s} + ED_{f} \end{aligned}$$

$ED_{external}$ is the direct external irradiation received in a year. $ED_{internal}$ is the dose that will be received over the next 50 years (adults) or 70 years (children), from all radionuclides taken into the body in the current year, specifically:

ED_a is the estimated committed dose from radionuclides inhaled through the air,

ED_w is the estimated committed dose from radionuclides taken in by drinking water,

ED_s is the estimated committed dose from radionuclides taken in by eating soil,

ED_f is the estimated committed dose from radionuclides taken in by eating food.

To calculate the estimated committed dose from internal radionuclides, an equation of the following general form is used for each radionuclide for each pathway:

$$ED_x = C \times CR \times CF \times EF \times DCF$$

where,

ED_x = Estimated Committed Dose over 50 years (adults) or 70 years (children) from a specific radionuclide taken into the body in the current year (*Sv*) for a specific pathway "x" (air inhalation, and water, soil or food ingestion).

C = Concentration of the radionuclide in the exposure pathway being considered (e.g., *Bq*/L for radionuclides in water).

CR = Contact Rate: The amount of water, food, air, etc., which is taken into the body in one day. Typical units for food are grams per day (g / day) and litres per day (L / day) for water.

CF = Conversion Factor: The factor of 365 days is required to convert the Contact Rate (CR) from units/day to units/year.

EF = Exposure Factor: This factor indicates how often the individual is exposed during a year. It is needed especially when exposure does not occur daily, such as at work (only five days a week) or when related to seasonal activities (swimming in the summer).

DCF = Dose Conversion Factor: This factor converts the amount of radionuclide taken into the body via inhalation or ingestion, in becquerels, to the extended 50-year (adults) or 70-year (children) dose in sieverts. DCFs are usually expressed as *Sv/Bq*.

4. DOSE AND RESPONSE

The relationship between the amount of a contaminant that is given (the dose) and the health effect (the response) is referred to as the dose-response relationship. The relationship between the two is a key consideration in understanding how contaminants can cause adverse health effects. The main factors that influence any dose-response relationship are the amount of a contaminant received and its toxicity, the route of exposure (i.e., inhalation, ingestion, dermal contact), and the frequency and duration of exposure. Is it short term (e.g., minutes, hours) or long term (e.g., years)? Short-term exposures are often referred to as acute exposures, whereas long-term exposures are called chronic exposures.

The dose is the amount of a contaminant that a test animal is administered or an individual is exposed to. It is usually expressed as the weight of the substance (g, mg) per unit of body weight (e.g., mg/kg).

Because every individual reacts differently to a contaminant, the dose-response relationship cannot be used to predict exactly when a particular health effect will begin in a particular individual. Instead, researchers speak of the chance or risk that a health effect will occur as a result of exposure. As the dose increases, the chance or risk of health effects for any particular individual also increases.

Different kinds of hazardous substances can vary widely in their toxicity or ability to cause adverse health effects. Theoretically, there is no compound that cannot produce a toxic response if the amount is large enough. For example, ordinary table salt might be toxic to humans, but only if a very large amount was to be eaten all at once (i.e., around 300 g for an adult). If a very small dose causes an effect, a contaminant is said to be more toxic than a substance that causes health effects only when the dose is very large. Botulinum toxin, for example, is extremely dangerous even in minute amounts (the lethal dose is about 0.00001 mg/kg body weight), and causes several food poisoning deaths each year in Canada. Fortunately, only a few substances are very toxic and choices can be made as to what risk of health effects we want to tolerate.

The acute toxicity of different substances is often expressed as a LD_{50} (Lethal Dose - 50). This is the amount of a substance that will kill 50% of test animals, such as rats. It should be noted that LD_{50}'s are usually calculated using a single oral (by mouth) dose to an experimental animal. In real life, exposure levels are always much lower and exposure can occur over days, weeks, months or even years (i.e., not a single dose) and may involve different or even multiple routes of exposure. As well, although there are many similarities between the way rat and human bodies function, they are not identical. Thus, it is always necessary to interpret the results for human health. Nevertheless, LD_{50}'s are a useful means of judging how acutely toxic one substance is relative to another, but are not very useful when trying to determine the long-term effects of exposure to lower non-lethal doses of chemicals. Other laboratory animal tests can be used to assess the effects of long-term exposure. Some examples of the LD_{50}'s of substances are shown in TABLE 1 below.

TABLE 1:

Examples of LD_{50}'s of Several Common Substances in Laboratory Rats

Substances	LD_{50}'s*	Toxicity
Table salt	3000	Low
Aspirin	1500	↓
Phenobarbital	660	
DDT	150	
Lead	100	
Tetraethyl lead	35	
Potassium cyanide	10	High

* LD_{50}'s are usually expressed as the number of milligrams of the substance per kilogram of body weight.

For more information on measuring ionizing radiation, see ***Appendix D****.*

The concept of the LD_{50} can also be applied to doses from ionizing radiation, although it is defined slightly differently than for chemical contaminants. Rather than being expressed as the amount of a substance ingested per kilogram of body weight, the LD_{50} for ionizing radiation is defined as the amount of energy imparted to tissue by ionizing radiation, measured in joules per kilogram of body weight. This quantity is called the *absorbed dose* of radiation and is measured in grays (Gy, 1 Gy = 1 joule per kilogram). The LD_{50} for acute, whole-body exposures in the absence of medical care is about 3 to 5 Gy, although with modern medical treatment, lives can often be saved following doses as high as 8 to 10 Gy. Doses of this magnitude are exceptionally high and could be received only under severe emergency situations.

Most of the time, chemical contaminants are excreted in a slightly modified form or as metabolic byproducts. If they are not excreted, contaminants or their byproducts are stored in the body where they can bioaccumulate in tissue. Health effects may not become obvious until a certain level is reached. Sometimes, contaminants can take many years to cause health effects. The time between the first exposure and the observation of a health effect is called the **latency period**. Many types of cancer can have latency periods of 20 to 30 years.

Many persistent toxic organochlorine chemicals, such as PCBs, are stored in fat tissue, whereas some metals, such as lead, are stored mostly in the bone. Other tissues and organs that often store chemicals include the liver, kidney and brain. Some chemicals can also build up in mother's milk, which can be an important exposure pathway for nursing infants.

Methods of Investigating Dose-Response Relationships

The dose-response relationships of chemical contaminants are investigated primarily by toxicological studies using laboratory animals. In some instances, when the data are particularly clear and convincing, human epidemiological studies can be used to provide information on dose-response relationships. Such human studies include occupational health and clinical studies, and those on accidental poisonings. In most other studies on humans, there is not enough information to establish actual dose-response relationships, because of the difficulty in controlling and quantifying the exact exposure and the consequent response. Toxicological and epidemiological studies are described below.

Toxicological Studies

Toxicological studies provide indirect information about the potential health effects of toxic substances in humans. These studies are carried out on laboratory animals or use other models to approximate the effects on human health. Exposures and doses of the contaminants can be carefully controlled in these studies.

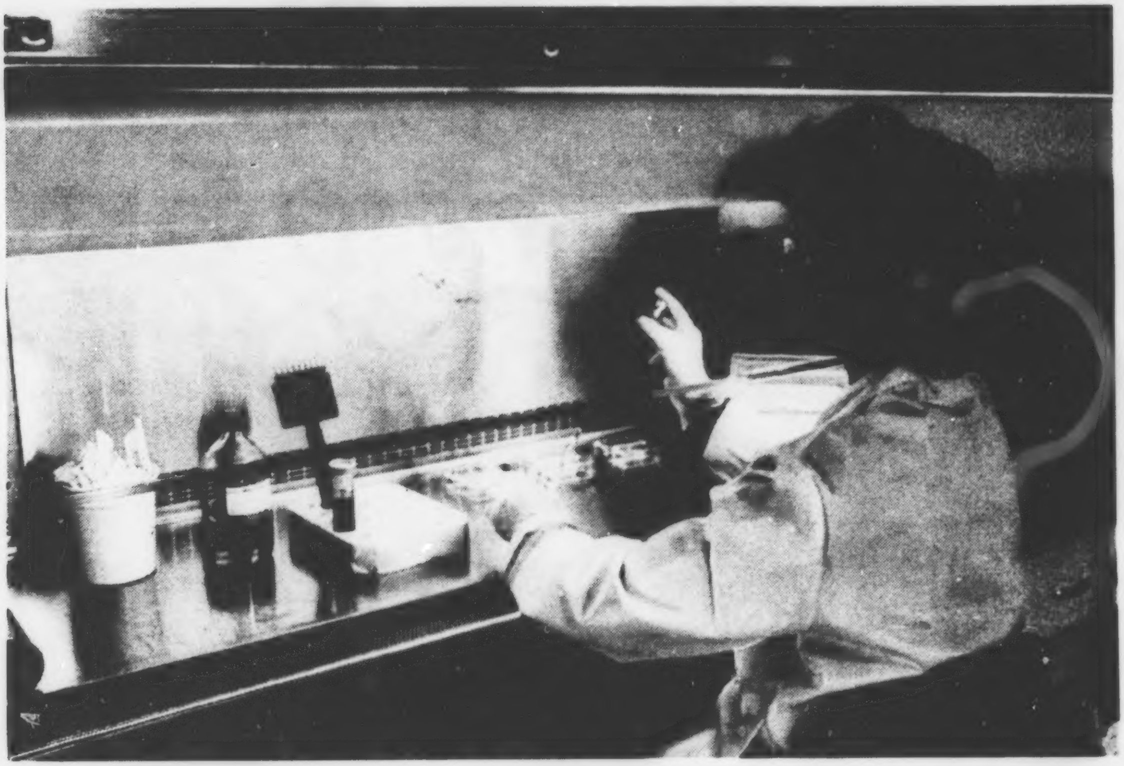
Some of the more common types of toxicological studies are outlined below:

- *Acute toxicity studies* examine the health effects of a single large dose of a substance given to the test animal. They are used mostly to determine what short-term specific health effect a substance produces in order to compare it with the acute toxicity of other substances, and to help determine lower dosages to be used in long-term studies.

- *Subchronic toxicity studies* examine the health effects of longer exposure to smaller doses of a substance. Periods of 90 days or longer are generally chosen. By using several exposure levels, the exact relationship between dose and the health effect is explored.
- *Chronic toxicity studies* and *carcinogenicity bioassays* look for health effects that occur only after a very long exposure to a substance. Most health effects become evident during the subchronic studies, but certain effects that develop very slowly (e.g., cancer) may appear only after exposures which last most of a lifetime. Chronic toxicity studies are the most important in assessing potential health risks to humans, since the experimental conditions are similar to those in which the general population is routinely exposed, that is, long-term, low-level exposure to chemicals and radioactivity.
- *Metabolic and pharmacokinetic studies* determine what happens to a substance inside a living organism, that is, how quickly it is absorbed and metabolized, transported through and excreted by the organism. The results of such studies are used to help interpret the results of other studies and to compare tests on different kinds of living organisms.
- *Genetic toxicological studies* look for genetic changes in bacteria, fungi, plants, insects, small mammals or cells of mammals that have been grown in a special culture. Although the tests are short-term, they can identify genetic mutations.
- *Structure-activity analyses* take the chemical structure of a contaminant, and attempt to predict toxic or carcinogenic effects based on the chemical and physical properties of the contaminant and its molecular structure. Examples of such properties include the types of chemical bonds or the number of chlorine atoms in organochlorine compounds. Such studies have had some limited success, but they are far from perfect.

Epidemiological Studies

Epidemiology is the study of disease patterns in populations and what factors influence these diseases. The simplest form of an epidemiological study looks at the patterns of illness (morbidity) and death (mortality) in a defined human population, and examines the possible factors that could be contributing to them. For obvious ethical reasons, people cannot be used to test the health effects of most environmental contaminants. Therefore, observational studies are generally used to investigate the health effects caused by past or ongoing exposures to environmental contaminants.



The most common types of observational epidemiology studies are summarized below:

- *Ecologic studies* examine the distribution of a particular health effect across areas or regions. They make use of existing large databases like cancer registries or disease incidence databases. In an ecologic study, information about the health and exposure of each individual is not known. Instead, the study compares disease rates in the entire population in each region and can identify unusual excesses of disease by area. Ecologic studies cannot adequately control for possible confounding factors, such as lifestyle (e.g., smoking or diet), that can contribute to disease. Therefore they cannot, by themselves, establish a cause and effect relationship. Rather, the studies are useful for identifying differences in disease rates, and can lead to hypotheses about the reasons for the differences. The hypotheses may then be investigated more rigorously in further studies.
- *Cross-sectional studies* determine the presence or absence of health problems, and the presence or absence of exposure in a subset of the population in the study. They are often carried out using questionnaire surveys, and confounding factors, such as

lifestyle (e.g., smoking, diet), can be evaluated for each individual, providing a better understanding of the factors affecting the disease being investigated. If the disease is very rare, the number of people required to adequately study the relationships becomes very large.

- *Case-control studies* look at the relationship between a disease and possible causes by comparing a group of individuals who have, or have had, the disease with a group which do not. For each individual in each group, the study obtains information about past exposure to contaminants and other lifestyle factors, and then compares the groups to see if there are differences in exposure rates while considering all other factors. Case-control studies are among the most common form of epidemiological study.
- *Cohort studies* compare a group exposed to an agent to a non-exposed or less exposed group, and determine the difference in disease incidences between the two groups. The population groups are called cohorts. The prospective study follows the individuals in that cohort forward in time, recording the incidences of disease as they occur. A retrospective study compares the disease outcomes in the two cohorts, backwards in time, long after the exposure has occurred. Cohort studies are commonly used to examine the effects of occupational exposures on groups of workers.

Epidemiological studies can collect new information or they can be based on historical data. Records from hospitals, disease registries, health insurers and Statistics Canada all provide data for large-scale epidemiological studies, once personal information has been removed. Similarly, useful information can be obtained by linking existing computerized databases (e.g., comparing records of cancer mortality to those for occupational exposure to radiation).

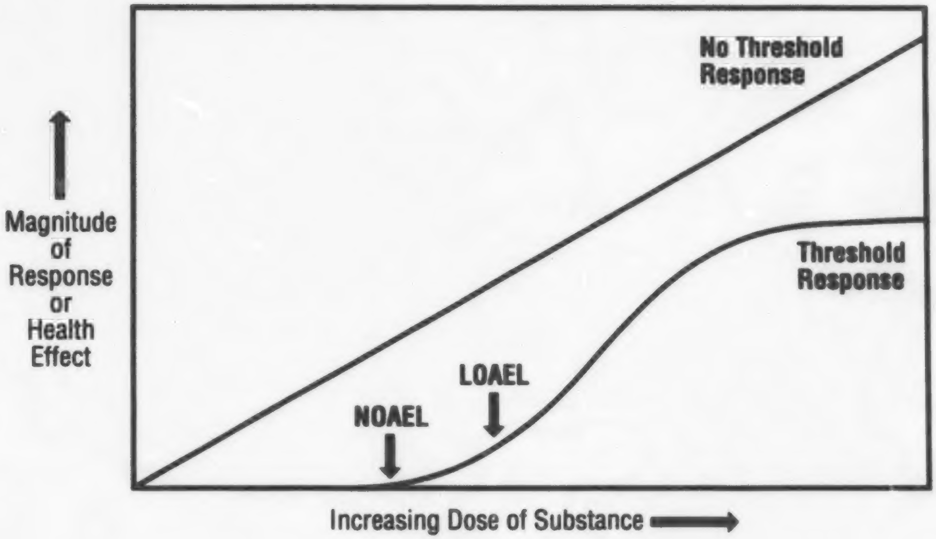
For more information on understanding the risk of disease from exposure to contaminants, as described in epidemiological studies, see ***Appendix B***.

Epidemiological studies have drawbacks. Even with sound methods and a statistically significant association between exposure and incidence, a cause-and-effect relationship cannot be categorically stated. Epidemiological studies, even relatively large ones, can be insensitive to small effects. Also, studies may have to continue for many years to adequately assess disease development in exposed populations (e.g., studies of suspected carcinogens). Although these studies have drawbacks, it is always preferable to have good epidemiological studies when assessing the toxicological risks to humans. Even with good quality data from animal studies, there is still uncertainty in extrapolating the potential risks to human health.

The results of toxicological and epidemiological studies are used to determine the dose-response relationship of individual chemicals. For some substances, no health effects can be observed when the exposure dose falls below a certain level. This level is called the threshold dose. For others, especially some substances which cause cancer by directly affecting the genetic material of the cell, there is thought to be no threshold dose. In these cases, there is assumed to be a risk, though extremely minute, of developing cancer even at very low doses. Threshold and non-threshold types of dose-response relationships are shown in FIGURE 5 below.

FIGURE 5:

Dose-Response Relationships



NOAEL - No Observed Adverse Effect Level - The level of exposure to a chemical at which no adverse effects are observed during studies with laboratory animals or in human epidemiological studies.

LOAEL - Lowest Observed Adverse Effect Level - The lowest level of exposure to a chemical at which adverse effects are observed during studies with laboratory animals or in human epidemiological studies.

For substances that do not cause cancer, or for the non-carcinogenic effects of substances that cause cancer, a level of exposure can be estimated below which effects on human health are not expected. For these substances, toxicological studies on laboratory animals and epidemiological studies are used to establish what is called the No Observed Adverse Effect Level (NOAEL), where the concentration of the substance does not lead to any adverse health effects, or the Lowest Observed Adverse Effect Level (LOAEL), which is the lowest concentration of contaminant at which adverse health effects are observed. This threshold dose is then converted to a dose considered tolerable by humans by using an uncertainty factor (UF). The uncertainty factor takes into account the difficulty of applying animal test results to humans, the differences between individuals in the way they react to and process substances, and the amount of experimental data available to assess these substances. By dividing the animal NOAEL or LOAEL by the uncertainty factor - usually by 100, sometimes as high as several thousand - a tolerable daily intakes (TDI) for humans is calculated. The tolerable daily intake is a value that implies that exposure over a lifetime above this level may lead to increased risk to health, based on the best existing scientific evidence. The risk from short-term exposures above the TDI is likely to be minimal.

$$\boxed{\text{TDI} = \frac{\text{NOAEL or LOAEL}}{\text{UF}}}$$

A different approach than the TDI is required for chemicals known to cause cancer. Contaminants which are known carcinogens are generally assumed to have a non-threshold dose-response, so that there may be no level of exposure to these contaminants that does not present some risk to health. For these substances, a decision must be made as to how large a risk of cancer can be accepted, in order to set acceptable intake levels. Various acceptable levels of risk are currently being used around the world, depending on specific circumstances. Such levels often vary between one extra cancer death per 10,000 people exposed to the contaminant over their entire lifetime, to one extra cancer death per million people exposed.

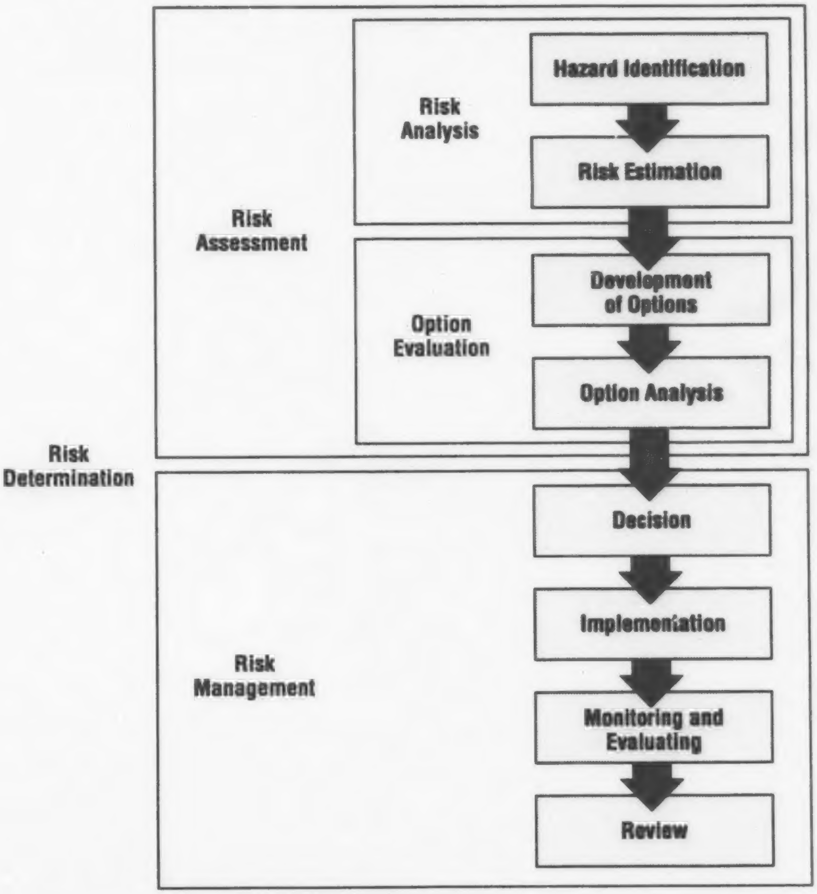
Once an acceptable level of risk has been established, it is possible to calculate a dose that people can be exposed to on a daily basis over their entire lifetime that will not exceed the accepted level of risk of cancer. In other words, if people are exposed to an amount of a carcinogen every day of their life that lies below this calculated dose, then their risk of cancer will lie below the acceptable level of risk. Because this "acceptable" dose is related directly to the decision about an acceptable level of risk, it is called the Risk-specific Dose (RsD). The Risk-specific Dose is calculated by dividing the accepted level of risk by a slope factor. Each carcinogen has its own slope factor which is determined from the results of laboratory and epidemiological studies. In essence, the slope factor states what the cancer risk is for every possible dose of the contaminant. The straight line in FIGURE 5 represents such a slope factor.

$$\text{Risk-specific Dose} = \frac{\textit{Acceptable Level of Risk}}{\textit{Slope Factor}}$$

When humans are exposed to chemical amounts that exceed the tolerable daily intake or the Risk-specific Dose, then there may be an unacceptable level of risk. Calculating and comparing such risk levels is called “risk analysis.” Risk analysis is the first step in a larger study called “risk determination.” Risk determination studies are used to weigh the health risks of contaminants against the benefits to society of the industrial processes or products that cause the contamination. The steps that Health Canada goes through in carrying out a risk determination are shown in Figure 6.

FIGURE 6:

Risk Determination: Steps in Risk Assessment and Management


Risk Determination
Risk Assessment
Risk Analysis
Hazard Identification
Risk Estimation
Option Evaluation
Development of Options
Option Analysis
Risk Management
Decision
Implementation
Monitoring and Evaluating
Review

Recommended Limits to Radiation Exposure

Limits for radiation exposure from artificial sources, in the public, have been issued by the International Commission on Radiological Protection (ICRP), and have been set at 1 *mSv* per year. Implicit in this limit is the understanding that exposures must be as low as reasonably achievable. This limit is in the process of being adopted by the Atomic Energy Control Board (AECB) of Canada. It applies to the total dose received from all internal and external sources, but does not include the natural background radiation that everyone is exposed to or exposures received for medical purposes. Actual doses received by the public from artificial sources are much lower than this limit. Artificial sources include levels of natural radionuclides that have been enhanced due to human practices such as uranium mining. In addition, the total dose at the site boundary of nuclear facilities may not exceed 0.05 *mSv* in a year as stipulated by the AECB. By comparison, the dose received from the natural background radiation is about 3 *mSv* per year.

Health Canada has issued guidelines for radionuclides in drinking water. The total dose received from the consumption of drinking water should not exceed 0.1 *mSv* per year, and this includes the dose from all radionuclides that exist naturally in the environment, as well as those that are artificial. This level of dose corresponds to a theoretical risk of about five extra cancer deaths per million people exposed.

If you want to know more about risk, refer to the following books:

Health Canada. 1993. Health Risk Determination: The Challenge of Health Protection. *Health Protection Branch. Catalogue number: H49-40/1993E.*

Paustenbach D. J. (ed.). 1989. The Risk Assessment of Environmental and Human Health Hazards: A Textbook of Case Studies. *John Wiley and Sons, Toronto, Ont..*

5. WHAT EFFECTS DO CONTAMINANTS HAVE ON HEALTH?

This section summarizes some of the major health effects that have been associated with selected contaminants in the environment. A good overall reference is: *Toxic Chemicals in the Great Lakes and Associated Effects*. 1991. Volumes I, II and Synopsis. Environment Canada, Department of Fisheries and Oceans and Health and Welfare Canada. Catalogue number: En 37-95/1990-1E (Volumes I and II), En 37-94/1990E (Synopsis).

5.1 Chemicals

PCBs

PCBs have been found in human fat and milk of Canadians and people living in other countries around the world. However, there is not enough information to tell whether levels are increasing or decreasing. It is known that levels in people living in the Great Lakes Basin are about the same as those in people living elsewhere.

PCBs are actually a family of chemicals with very similar structures. Individual members of the family are called congeners. Not all PCBs are equally toxic. In animals, short-term high exposures can shorten the lifespan, be toxic to the liver, prevent normal growth and development, suppress the immune system, and cause reproduction problems and cancer. The actual effect depends on the dose and type of PCB. It is unlikely that PCBs actually "start" cancer. It is more likely that they act as "promoters" once a cancer has already started to grow.

Until about 10 years ago, researchers thought that all PCBs were similar and were about equally toxic, so that only the total amount of all PCBs were measured. It is now known that different PCB "congeners" are not equally toxic. Therefore, it is difficult to tell how toxic the "total PCBs" of old studies really are. Today, PCB research is focusing on measuring levels of individual PCB congeners and understanding their effects.

General Reference: Kimbrough R.D. 1987. Human health effects of polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs). *Annual Review of Pharmacology and Toxicology* 27:87-111.

Dioxins and Furans

Like PCBs, dioxins and furans have been found in human fat and mother's milk. The most toxic type of dioxin/furan is called 2,3,7,8 - tetrachlorodibenzo-p-dioxin (TCDD), but its toxicity is different in different species. Guinea pigs are the most sensitive species found so far, and hamsters the least. High exposures in animals cause a skin disease called chloracne, weight loss, effects on the thymus gland (used to keep the immune system functioning correctly) and death. Longer term exposures can cause liver damage, weight loss, effects on reproduction, the immune system and normal development. Lifetime exposure of laboratory rats and mice has resulted in increased occurrence of cancer in the liver and other organs. However, like PCBs, it is thought that dioxins and furans "promote" cancer that has already started to grow.

Accidental exposures of people to dioxins and furans, such as at Seveso, Italy and in Vietnam, have caused chloracne, but reports of cancer and developmental effects have been called into question. Dioxins and furans usually come as mixtures of different types. Since 2,3,7,8 - TCDD is the most toxic form, the toxicity of all other types of dioxins and furans is calculated by comparing them with the toxicity of 2,3,7,8 - TCDD. The toxicity of other dioxins and furans varies from about 0.001 (a thousand times less toxic) to 1.0 (equal toxicity).

General Reference: International Programme on Chemical Safety (IPCS). 1989. *Environmental Health Criteria 88: Polychlorinated dibenzo-para-dioxins and dibenzo furans.* World Health Organization, Geneva.

DDT and Its Breakdown Products

DDT and its breakdown products are found throughout the environment. DDT breaks down to DDE and other compounds. DDE is less toxic to humans than DDT, but it is more stable. DDE also has a stronger attraction to fat than DDT. Therefore DDE, rather than DDT, is the major contaminant stored in human tissues.

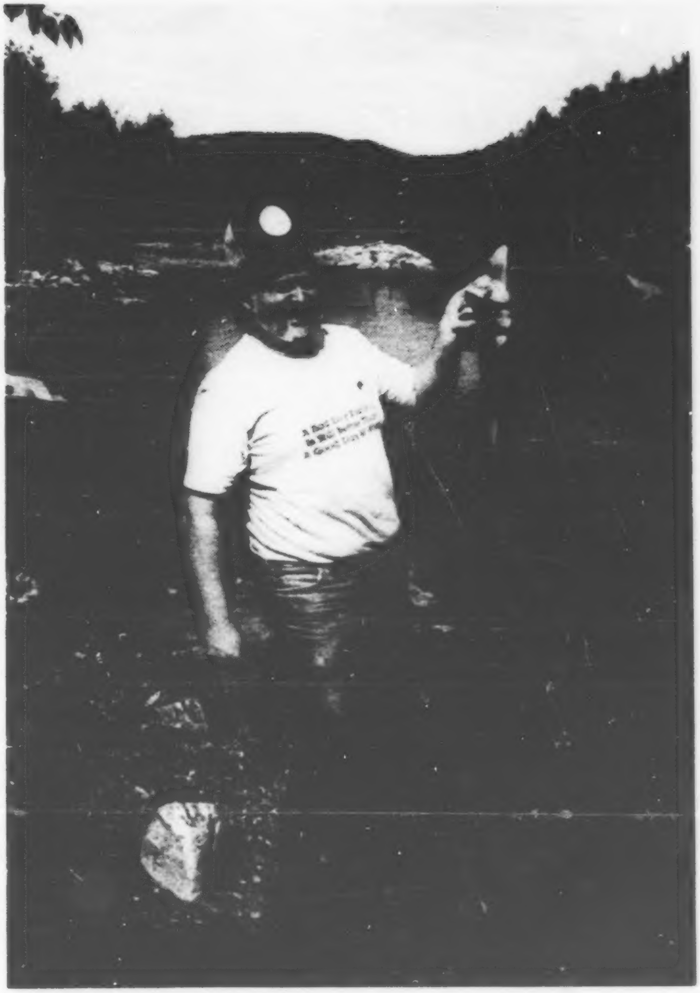
DDT and DDE cause several effects in animals including: liver enlargement and death of the liver, effects on the nervous, immune and reproductive systems and cancer. There is much less information about effects in humans. Only a few incidents of DDT poisoning have been reported. However, exposure to quite high levels of DDE in mother's milk may cause babies to have slower reflexes than normal.

General Reference: International Programme on Chemical Safety (IPCS). 1989. *Environmental Health Criteria 83: DDT and Its Derivatives —Environmental Aspects.* World Health Organization, Geneva.

Cadmium

Most cadmium is stored in the liver and kidneys. Because it cannot break down and is not easily expelled from the body, levels of cadmium tend to increase with age. The main long-term effects of low-level exposure to cadmium are reduced lung function, emphysema and kidney disease. There may also be effects on the circulatory system and skeleton. A disease called "itai-itai," first noticed in Japan, has been associated with eating low levels of cadmium over the long term. Itai-itai victims typically experience a softening of the bones, pain in the back and spontaneous bone fractures. There are also indications that cadmium can be carcinogenic. One study of battery workers in England found a relationship between exposure to cadmium and prostate cancer. Cadmium has been shown to be carcinogenic in several species of laboratory animals, including rats.

General Reference: Friberg L., Elinder C-G., Kjellström T., Nordberg G.F. (eds.). *Cadmium and Health: a Toxicological and Epidemiological Appraisal. Volume I: Exposure, Dose, and Metabolism* (1985) and *Volume II: Effects and Response* (1986). CRC Press, Boca Raton, Florida.



Mercury

Mercury can exist in three forms: as pure metallic mercury; in inorganic compounds such as mercuric chloride; and in organic compounds, like alkyl mercury. Inorganic mercury can be converted to organic mercury by bacteria and other living organisms, especially in lakes and rivers. The organic form can concentrate in fish and make the fish poisonous to humans.

Organic mercury is more toxic than either pure metallic or inorganic mercury. Two major epidemics of organic mercury poisoning have occurred in Japan, in Minimata Bay and in Niigata. Both were caused by mercury pollution from industry, and the subsequent build-up of mercury in fish which were then eaten. The largest recorded incident of organic mercury poisoning was in Iraq in 1971-72 when seed grain, coated with a mercury-based pesticide to keep it from rotting, was made into bread and eaten. Over 6,000 people went to hospital and there were over 500 deaths. In Canada, the health effects of mercury have been investigated in Indian and Inuit communities, where contaminated fish and wildlife were eaten. Although severe organic mercury poisoning was not found, many of the reported symptoms suggested mild poisoning.

The early symptoms of mercury poisoning include a prickling or tingling feeling in the hands or feet, tunnel vision and slurred speech. In animals, inorganic mercury has been associated with kidney damage and abnormal growth and development. Both inorganic and organic forms of mercury are thought to affect the immune system.

General Reference: Goyer R.A. 1991. Toxic effects of metals. In Amdur M.O., Doull J., Klaassen C.D. (eds.). *Casarett and Doull's Toxicology: The Basic Science of Poisons, 4th ed.* Pergamon Press, New York.

5.2 Microorganisms

Bacteria, viruses, protozoa and fungi can cause a wide variety of health effects that range from being insignificant, such as a runny nose, to being fatal. Bacterial, viral, protozoan and fungal infections can occur almost anywhere in the body. However, bacteria, protozoa, and perhaps viruses, in contaminated water are associated with ear, eye, nose and throat infections, skin problems and upset digestion.

General Reference: Burton G.R.W. 1992. *Microbiology for the Health Sciences, Fourth Edition*. Lippincott, Philadelphia.

5.3 Radiation

The health consequences of ionizing radiation depend on the size of the dose received and the duration of exposure. For exposure to radiation at the low levels generally found in the environment, the duration of exposure is of most concern. The main health effects associated with chronic (long-term) exposures at these levels are the development of various cancers such as in the bone, thyroid or lung, as well as cataracts of the eye. Cancers caused by radiation may not appear for several decades after exposure. Radiation-induced cancers are indistinguishable from those that occur for other reasons. Although there is a small risk of hereditary effects, no conclusive evidence for these effects, attributable to either natural or artificial radiation, have been found in human offspring.

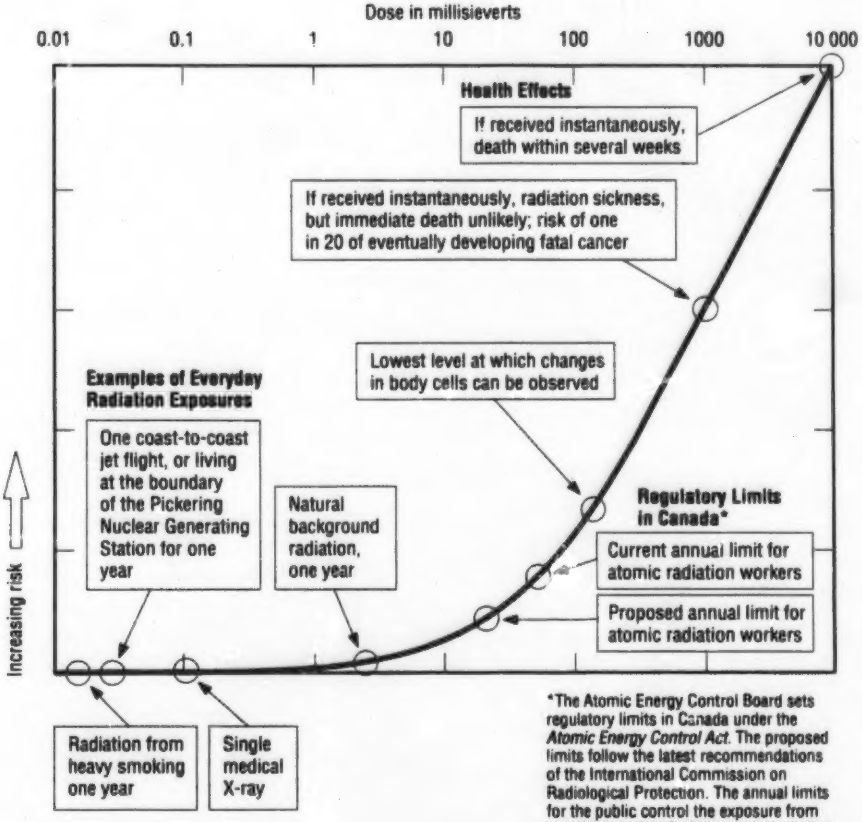
It is generally assumed that even the smallest dose of ionizing radiation poses a potential risk of cancer, and that this risk is proportional to the dose received. However, this assumption is simple and there is considerable evidence that it is also conservative.

Ultra-violet radiation can cause skin cancer and cataracts. There is some evidence that the increase in UV radiation caused by the thinning of the ozone layer is resulting in more cases of skin cancer and cataracts. The effects of electromagnetic fields on health are not clearly understood. Some studies suggest a weak association between increased risk of certain cancers (e.g., leukemia, brain cancer) and exposure to electromagnetic fields.

General Reference: Hendee W.B. 1984. *Health Effects of Low-level Radiation*. Appleton-Century-Crofts, Norwalk, Connecticut.

FIGURE 7:

Radiation Exposure and Limits



*The Atomic Energy Control Board sets regulatory limits in Canada under the *Atomic Energy Control Act*. The proposed limits follow the latest recommendations of the International Commission on Radiological Protection. The annual limits for the public control the exposure from regulated nuclear facilities such as nuclear reactors. These limits are in addition to the natural background radiation.

5.4 Particulate Matter (Dust)

There seem to be three ways that particulate matter is harmful:

- some of the particles themselves may be toxic or have toxic elements adsorbed onto the particle;
- too many particles within a short time can tax or overwhelm the ability of the lung to clear itself of unwanted substances; and
- the particles may interact with other pollutants in the air and act synergistically, that is, the effect of two or more contaminants acting together is greater than the sum of effects attributable to each contaminant.

In general, particulates deposited in the respiratory system are thought to aggravate already existing lung and heart disease. Some researchers claim that other body defence mechanisms are also affected. Children, the elderly, asthmatics, smokers, people suffering from heart disease and those with the flu or bronchitis may be at particular risk when particulate levels are high.

5.5 Health Effects of Special Concern

In most epidemiological and toxicological studies of environmental contaminants, only a relatively small range of health effects have been investigated. Many studies have examined the ability of contaminants to cause cancer, either in human populations or in experimental animals. As well, mutagenicity (i.e., a contaminant's ability to change the inheritable genetic material, DNA) is often studied using bacterial cultures.

To date, the public has been most concerned about the ability of toxic chemicals, such as PCBs and dioxins, to cause cancer. However, a growing amount of scientific evidence suggests that contaminants can be associated with many other less noticeable health effects.

Within the last 20 years, studies on wildlife in the Great Lakes Basin and elsewhere have shown that newborn animals were less healthy after their parents had been exposed to mixtures of persistent chemicals. The health effects observed include behavioural changes, weight loss and deformities. There is also some information on human populations exposed to contaminants that partially agrees with the wildlife studies.

The scientific research now suggests that as well as studying mortality and cancer, other health effects should be investigated, particularly those that are related to growth and development - both physical and behavioural. There have been some efforts to investigate birth defects, and greater emphasis is being placed on less noticeable developmental changes, including learning ability, memory and behaviour as well as physical effects.

In many communities in the Great Lakes Basin and elsewhere, a growing concern is the increase in respiratory problems and allergies, particularly in children. For example, more cases of asthma and related conditions in children living in urban areas have been documented. While it can be difficult to prove that specific contaminants in the environment cause specific health effects, it will be important to monitor these types of health problems in relation to the presence of environmental contaminants.

TABLE 2 summarizes some of the health effects that are of special concern for environmental contaminants.

TABLE 2:

Health Effects of Special Concern for Environmental Contaminants

HEALTH EFFECTS	DESCRIPTION
Cancer	• over a hundred different types • contaminants are cancer "initiators," others "promoters"
Mutagenicity	• changes in the inheritable genetic material
Teratogenicity	• affects the growth and development of the children of the person who has been exposed (e.g., acute exposure to PCBs)
Reproductive Impacts	• reduced fertility: reduced ability to produce healthy eggs or sperm. For example, the men working in a plant producing the pesticide dibromochloropropape (DBCP) became sterile • effects on reproductive organ development expressed during childhood or post-adolescence (e.g., dioxin) and reproductive tract disorders
Neurotoxicity	• affects the central and/or peripheral nervous systems, leading to adverse development and behavioural effects (e.g., the effect of lead on childhood learning) • direct effects on the nervous system (e.g., mercury affects vision and causes peripheral neuropathy)
Immunological Toxicity	• reduction of the body's ability to fight disease; allergies; auto-immune diseases
Respiratory Effects	• affects the respiratory system (i.e., the nose, throat and lungs)
Microorganism-related Effects	• affects the gastrointestinal system, respiratory system, eyes, ears and skin

6. DESIGNING AND CONDUCTING A COMMUNITY HEALTH SURVEY

A community health survey is one possible part of developing a community health profile. Surveys are undertaken only when existing data are inadequate or new information is needed. It is very important to check with experts and verify all sources of information before you decide to conduct a survey. Surveys require a great deal of time and effort, especially if many people are being surveyed.

To minimize the work and ensure results that are scientifically sound, health surveys must be well designed, thoroughly planned and thought through before proceeding. Seek some expert advice and try to consult with others who have done similar types of surveys. The following steps are usually considered when carrying out epidemiological surveys:

- designing the survey;
- planning for the survey;
- conducting the survey;
- interpreting the survey results; and
- disseminating the survey results.

Some of the main points addressed under each of these headings are summarized below:

CONFIDENTIALITY OF INFORMATION

Information collected in health surveys are often sensitive and personal. It is the responsibility of the investigators to ensure that the data collected from each survey respondent be kept confidential. For example, each respondent can be assigned with an identification number and the name and address can be kept separately from the questionnaire. All data should be kept under lock and key with designated people only having access.

Designing the Survey

A community health survey should follow basic scientific methods. These include defining the survey objective or the problem to be studied, defining the geographic area to be investigated and selecting the study sample, defining a control population and designing the survey tools such as questionnaires.

Defining Survey Objectives

- What are you investigating in this survey? Is there a particular health effect or disease to be investigated? Is it a specific type of cancer, reproductive condition or other illness? Do you want to find out what your community's health status is?
- What type of survey would be best? There are two main types of survey - interview and self-administered. In interview surveys, a trained person interviews people either in person or over the telephone. In self-administered surveys, the people being surveyed fill out the survey form themselves and return it. The self-administered approach avoids concerns about possible biases of the interviewer. On the other hand, an interview survey usually gets a higher proportion of the people to respond.

Area and Sample Selection

- What area do you include in your survey? Depending on the nature of the health concerns, geographic boundaries that make sense must be established.
- Who do you survey? Will all the people in the study area be surveyed or will a representative group (known as a sample) be selected? For practical reasons, it is not likely that every person can be surveyed, especially in large communities. The focus of the survey must be established and could, for example, include households, people working at the same place, people living in the same neighbourhood or children attending the same school.
- How will you select the sample? The people in the sample must be chosen in a way that does not make your survey biased. In other words, the people in the study area who will be interviewed should be picked randomly, rather than choosing all those who you know are unhealthy.

Defining a Control Population

- Who will you compare your survey results against? Do you want to survey a second group of people (control group) that resembles your survey population in every way, except for the suspected environmental contaminant or factor? This control group should have the same age and sex distribution and socio-economic makeup as your survey population. Such a population may be difficult to find within your community, but its inclusion will add to the strength of the survey.
- Health statistics collected by government and private agencies can also be used as a basis for comparing your survey data to standardized health. These data are usually analysed for major causes of death or illness and are often presented by age, sex and by various geographical areas (national, provincial, county or census subdivision).

Designing the Questionnaire

A questionnaire is often the primary tool used to collect information in a health survey. It is important that the survey questionnaire be well designed, specific to the problem being investigated, and thoroughly tested prior to starting the survey. It is recommended that questions from previously used standardized questionnaires be used. These can be adapted for your specific circumstance. An epidemiologist can be extremely helpful in designing questionnaires and health surveys.

Health surveys try to collect the following four types of information:

- demographic characteristics;

- exposure history;
- health effects; and
- confounding factors.

The types of questions which can be used to collect this information are presented below. This list is lengthy but not exhaustive and should be adapted to the objectives of the study.

Demographic characteristics

- age and sex of the respondent;
- ethnic or cultural group (English, French, Native, Asian, African, etc.);
- occupation or type of work;
- total household income (usually in ranges of $10,000 to $15,000);
- type of neighbourhood (urban, suburban, rural, etc.);
- type of housing (single-family, multiple family, mobile home, etc.);
- number of years living at the present address and in the community;
- number of people living in the household; and
- education level of the respondent (last grade of school completed, college, university, etc.).

Exposure history

These include questions related to exposure pathways and routes such as:

- the source of drinking water (city, well, bottled);
- eating habits; and
- exposure at work and at home, and information on the extent of exposure to contaminants.

Occupational Information

- list of jobs, places of employment, the department and years of employment;
- list of main activity of the company or organization, the products and the industrial or production processes used;
- the type of place usually worked at (factory or plant, laboratory, vehicle, warehouse, outdoors, office, restaurant, hotel);
- specific tasks and materials used;
- the work surroundings (number of people, noise, temperature, machines, dust, fumes, smoke, gases);

- the use of oils, solvents, acids and detergents; and
- exposure to X-rays or microwaves.

Exposure to chemicals at work

- Acrylonitrile
- Arsenic
- Asbestos
- Benzene
- Beryllium
- Bis(chloromethyl)ether
- Ceramic dust or talc
- Coal tar pitch, volatiles
- Oils, asphalt
- Chemical fertilizers
- Coke oven emissions
- Dyes
- Lacquers, varnishes
- Lead
- Fibreglass
- Cotton, textile, wood, grain or metal dust
- Paints, glues
- Isopropyl oils
- Other petroleum products
- Radioisotopes or radioactive materials
- Insecticides, pesticides
- Herbicides, fungicides
- Chromium or chromat

Exposure to chemicals at home

- Plastics
- Metals
- Clay
- Wood
- Paper
- Stone
- Glazes
- Enamels
- Pastels
- Dyes
- Plaster
- Pigments
- Feathers
- Wax
- Glass
- Fixatives
- Oil paints
- Acrylic paints
- Alkyd paints
- Epoxy paints
- Aerosol or spray paints
- Lacquer, varnish
- Acid, caustics
- Solvents - turpentine, paint thinner, paint removers
- Glues, adhesives, resins
- Solder
- Photography chemicals
- Pesticides, insecticides, fungicides, herbicides, fumigants

Neighbourhood Information

- Water:
  - Unusual taste or smell
  - Corrosive
  - Hard
  - Use of water softener
  - Use of charcoal filter or ion exchanger
- Outdoor air quality:
  - Clear
  - Haze
  - Light smog
  - Moderate smog
  - Heavy smog
  - Occasional dust or smoke
  - Frequent dust or smoke
  - Occasional or frequent chemical smell
- Indoor air quality in household:
  - Tobacco smoke in the house
  - Use of floor wax, furniture polish and oven cleaners
  - Use of gas stoves, wood-burning stoves and unvented gas space heaters for heating
  - Use of roach spray, insecticides and foggers

Health effects

Questions to detect health effects that could be related to exposure can be asked. Questions about unrelated health effects can also be asked to determine whether the people being interviewed on average tend to report more or fewer health effects than people in other communities.

Family medical history

Questions concerning the medical history of the respondent's close relatives, such as grandparents, parents, siblings and cousins, can be asked. These can include the incidence of allergies, asthma, diabetes, heart trouble, stroke, thyroid problems, ulcers and many other conditions among the respondent's family.

Respondent's medical history

Questions concerning the respondent's medical history which could include symptoms and diagnosed conditions of the following:

- Respiratory system:
  - Tuberculosis
  - Pneumonia
  - Persistent bronchitis
  - Emphysema
  - Pneumoconiosis
  - Lung disease
  - Persistent cough
  - Productive cough (phlegm, sputum)
  - Chest pain
  - Coughing up blood
  - Difficult or laboured breathing
  - Wheezing or asthma
- Cardiovascular system:
  - Heart attack
  - Heart disease
  - Low blood pressure
  - High blood pressure
  - Stroke
  - Hardening of the arteries
  - Other disease of veins or arteries
  - Vasculitis
  - Thrombophlebitis
  - Rapid or irregular heartbeat
  - Heart murmur
- Blood:
  - ITP
  - Anemia
  - Infectious mononucleosis
  - Malaria
  - Condition of the spleen
  - Dialysis or pheresis
  - Abnormal blood count
  - Blood transfusion
  - Coagulation or clotting disorder

- Digestive system:
  - Gallstones
  - Ulcers
  - Hepatitis
  - Jaundice
  - Cirrhosis of liver
  - Other conditions of liver or pancreas
  - Esophageal atresia
  - Frequent nausea or vomiting
  - Chronic indigestion
  - Colic or abdominal cramps
  - Frequent diarrhea
  - Frequent constipation
  - Loss of appetite
  - Loss of weight
  - Alcohol or food intolerance
- Urinary tract:
  - Kidney condition
  - Bladder disease
  - Protein in urine
  - Frequent or painful urination
  - Blood in urine
- Endocrine/glandular system:
  - Diabetes
  - Thyroid condition
  - Any hormonal condition
  - Excessive sweating
  - Hypoglycemia
- Skin:
  - Psoriasis
  - Eczema
  - Dermatitis
  - Unusual rashes
  - Red, scaly, dry or itching skin
  - Unusual acne
  - Hives, unusual flushing
  - Patches of greater or less pigmentation
  - Easy or spontaneous bruising
  - Small, round purple or red spots
- Immune system:
  - Hay fever
  - Asthma
  - Food allergies
  - Allergic dermatitis or skin rashes
  - Frequent colds or infections
  - Chemical intolerance
- Head and neck:
  - Excessively oily or brittle hair
  - Unusual loss of hair
  - Nasal soreness, sinus troubles or infections
  - Excessive salivation
  - Prolonged sore throat
  - Dry throat
  - Difficulty in swallowing
  - Unusual taste in mouth
  - Excessive dental cavities
  - Excessive tooth loss
  - Swollen or sore gums
  - Ears (itching, pain or discharge)
  - Head injuries
  - Eyes (red, itchy, watery, sore, dry, inflamed, blurred vision, constricted pupils, cataracts, glaucoma)

- Nervous system:
  - Epilepsy or seizures
  - Headaches
  - Dizziness
  - Weakness, fatigue
  - Lethargy, drowsiness
  - Decreased sensory perception (smell, taste, hearing, vision, touch)
  - Colour vision
  - Numbness, tingling, prickling, other sensations on skin
  - Tremors, cramps, spasms
  - Problems with balance, coordination, reaction time, clumsiness
  - Anxiety
  - Depression
  - Trouble sleeping
  - Irritability
  - Hyperactivity
  - Restlessness
  - Learning disorder
  - Memory or personality changes
  - Frequent nightmares
  - Meningitis
  - Peripheral neuropathy
- Muscles and bones:
  - Arthritis/rheumatism
  - Limb pain, hand or foot
  - Stiffness in joints
  - Broken bones
  - Numbness, weakness in feet and arms
  - Leg cramps
  - Muscular dystrophy
  - Multiple sclerosis
- Other symptoms or diagnosed conditions:
  - Cancer
  - Leukemia
  - Hodgkin's disease
  - Any metabolic disorder
  - Fever
  - Chills
  - Unexplained loss or gain in weight
  - Overweight or underweight
  - Frequently feel warmer or colder
  - Cysts
  - Accidents that required medical care (including athletic injuries)
  - Serious infections
- Female diagnosed conditions:
  - Menopause
  - Irregular periods
  - Premenstrual syndrome
  - Female hormones (estrogen) prescribed
  - Disorder of cervix
  - Disorder of uterus
  - Disorders of ovaries
  - Venereal disease
  - Infertility
- Male diagnosed conditions:
  - Sterility
  - Abnormal sperm count
  - Sexual disturbances or problems
  - Venereal diseases

- Reproductive history (women):
    - Past and current pregnancies
    - Number of pregnancies
    - Number of babies born
    - Ability to become pregnant
    - Sterility and menopause
    - Current use of birth control
    - The gender of each baby
    - Normal vaginal birth
    - Cesarean
    - Stillbirth
    - Abortion (induced)
    - Twins (both live), twins (one live, one stillborn)
    - Other multiple outcome
    - Tubal pregnancy
    - Low birth weight baby (less than 5 1/2 pounds or 2500 grams)
    - Premature birth (less than 37 weeks)
    - Miscarriage

    The condition of each baby at birth or apparent shortly afterward that involved:

    - Extremities (arms, legs, hands, feet)
    - Skin rashes or darkened skin
    - Moles and birthmarks
    - Molding (head)
    - Eyes
    - Cleft lips
    - Cleft gums
    - Cleft palate
    - Ears (abnormalities)
    - Thorax (large, small)
    - Lungs (not fully inflated, difficulty breathing)
    - Heart (abnormal rhythm, murmur, valve defect)
    - Liver (jaundice)
    - Spleen
    - Kidneys
    - Skeletal muscles
    - Bones
    - Joints
    - Stomach
    - Intestines
    - Throat
    - Genitals
    - Brain (cerebral palsy, spinal or nervous system condition)
    - Mental condition
    - Reflexes – abnormal
    - Metabolic disorder
    - Chromosomal disorder

Children's health (persons through 18 years of age)

- General health (excellent, good, fair or poor)
- Resistance to illness
- Previous serious illnesses
- Nervousness
- Anxiety
- Restlessness
- Depression or moodiness
- Hyperactivity
- Ability to concentrate
- Learning or reading disorders
- Allergies
- Asthma
- Metabolic conditions
- Height, weight
- Speech
- Coordination

Children's health cont'd. (persons through 18 years of age)

- Reading
- Physical and mental development at various ages
- Limits to amounts of play or vigorous activity due to health

Confounding factors

These are other factors that could also lead to similar health effects as exposure to a contaminant. Such factors "confound" the study because they make it difficult to prove that the reported health effects were caused by the contaminant. They include smoking, alcohol consumption, use of medications and pre-existing health problems. Some examples are provided below.

Major medications

- Allergy shots
- Atrovent
- Diazepan
- Halcion
- Insulin
- Levothyroxin
- Propanolol
- Provera
- Prozac
- Salbutamol
- Tetracyclin
- Tylenol
- Ventolin

Radiation history

- Screening (chest, mammography, dental)
- Diagnostic (what body part, how many, when)
- Therapeutic (what type, what underlying condition, how many treatments, when)

Lifestyle information

- Special or restricted diet
- Smoking cigarettes, pipes and cigars, chewing tobacco, snuff
- Use of recreational drugs (e.g., amphetamines, barbiturates, marijuana)
- Alcohol use (e.g., beer, wine, spirits)

Planning for the Survey

- What kind of people do you need? Typically, the following types of people are needed to carry out a survey: project managers or team leaders, statisticians or epidemiologists, toxicologists, interviewers, people to deal with the media and to perform communication activities, data entry clerks and clerical help.
- Where will the survey office be located? In someone's home, in a community centre or at the local college? You will need a phone

number for people to contact to obtain information and an address to receive correspondence.

- What kind of materials and equipment do you need? Items may include desks, telephones, facsimile machines, photocopiers, computers (hardware and software), vehicles.
- What will the budget be for the survey? What will the expenses be for each aspect of the study? Will you have to pay for people's time or will they be volunteers? Budget for expenses such as telephones, printing and photocopying, postage, equipment rentals, etc.
- Who will pay for the expenses? Will the money be raised from the community? Will there be some funds available from any government or community agency?

Conducting the Survey

Conducting a community health survey involves a series of steps, including:

- Public consultation and information activities include making an initial announcement in the community that a survey will be conducted and answering any questions from potential participants.
- Recruit survey participants and obtain their informed consent to participate.
- Recruit and train the survey workers to ensure the quality and consistency of the data being collected. This could involve training the interviewers on how to ask questions and how to fill out the questionnaires. Interviewers should be trained to remain non-biased, not to ask leading questions and to be consistent between interviews.

  All workers are made familiar with the study objectives and methods, and the process of data collection (questionnaires), as well as the entry of the data on computers.
- Administer the survey (either interview or self-administered). It is important that enough people respond to the survey. The level of participation in the community may be critical in the survey's success. Some scientists feel that an 80% level of participation of the chosen sample is necessary, while others believe that only 60% is adequate. However, with more responses you can have more confidence in your results.

Interpreting the Survey Results

Once the data collection phase is completed and all questionnaires have been received, the survey results are transferred to a master sheet. This is usually done by entering all the data on a computer file using a spreadsheet program or a statistical computer program, such as SAS or SPSS. All questionnaire data on the computer file should be verified to ensure that no data entry errors have been made.

The data that has been collected may not be easy to interpret and will require statistical analysis by someone with a background in epidemiology or statistics. In-depth data analysis can require a great deal of effort and can be time consuming. The outcome of this analysis could include the following:

- Summary data: The data are usually tabulated to give a summary of the results and tell you such things as how many people responded to the survey compared to the selected sample, how many people are in each age group, the number of male and female respondents, and the frequency of responses for each question. Specific health effects from questions asked in the survey will be tallied simply as the number of positive responses recorded.
- In-depth analysis: The summary data may provide some insights for further analysis. Analysis should be kept specific to the objectives identified in the planning stages of the survey. The incidence of health symptoms or diseases from the surveyed sample may be compared to the incidence in a control group or incidence in the county, province or country.

  At this stage, associations between health symptoms and possible causes may be examined. For example, the frequency of a particular respiratory symptom may be compared to levels of air pollutants in a community. These corresponding trends do not necessarily prove cause and effect, but may show where more detailed investigations are needed. Confounding factors such as smoking, alcohol and drugs should also be carefully considered in these analyses, since they can lead to many of the same symptoms or illnesses as environmental contaminants.

Disseminating the Survey Results

A study report is prepared after the survey is completed and the data analysed. The following are some items that can be included in the report:

- a description of the study's objectives, the methods followed and the population sampled;
- a summary of the data and the results obtained;
- a discussion of your findings, which includes the interpretation of your results;

- the conclusions drawn from the survey results;
- an executive summary of the study; and
- a public summary report on highlights of the study, written in lay language.

Once prepared, the report can serve as the basis for disseminating the results of the survey. Some of the people you might consider sending the results to could include:

- all the survey participants;
- the community at large in the area surveyed;
- the local public health unit;
- government officials (local, provincial, federal);
- all the people who have contributed to the study; and
- the media (radio, television, newspaper).

7. REMEDIAL ACTION PLANS (RAPs)

7.1 Overview

In 1985, the International Joint Commission's (IJC) Great Lakes Water Quality Board identified 42 Areas of Concern (AOCs) around the Great Lakes with an additional site designated in 1991. Sites have been listed as AOCs if one or more of 14 standard beneficial uses of the water resource, such as beach quality, restrictions on dredging due to levels of contaminants in sediments, etc., are impaired (see TABLE 3).

TABLE 3:

Restriction of Beneficial Uses in Areas of Concern

The impairment of beneficial uses with direct relevance to human health

- restrictions on fish and wildlife consumption;
- tainting of fish and wildlife flavour;
- restrictions on drinking water consumption, or taste and odour problems; and
- beach closings.

The impairment of beneficial uses with secondary relevance to human health

- degradation of fish and wildlife populations;
- restrictions on dredging activities;
- eutrophication or undesirable algae;
- degradation of esthetics; and
- added cost to agriculture and industry.

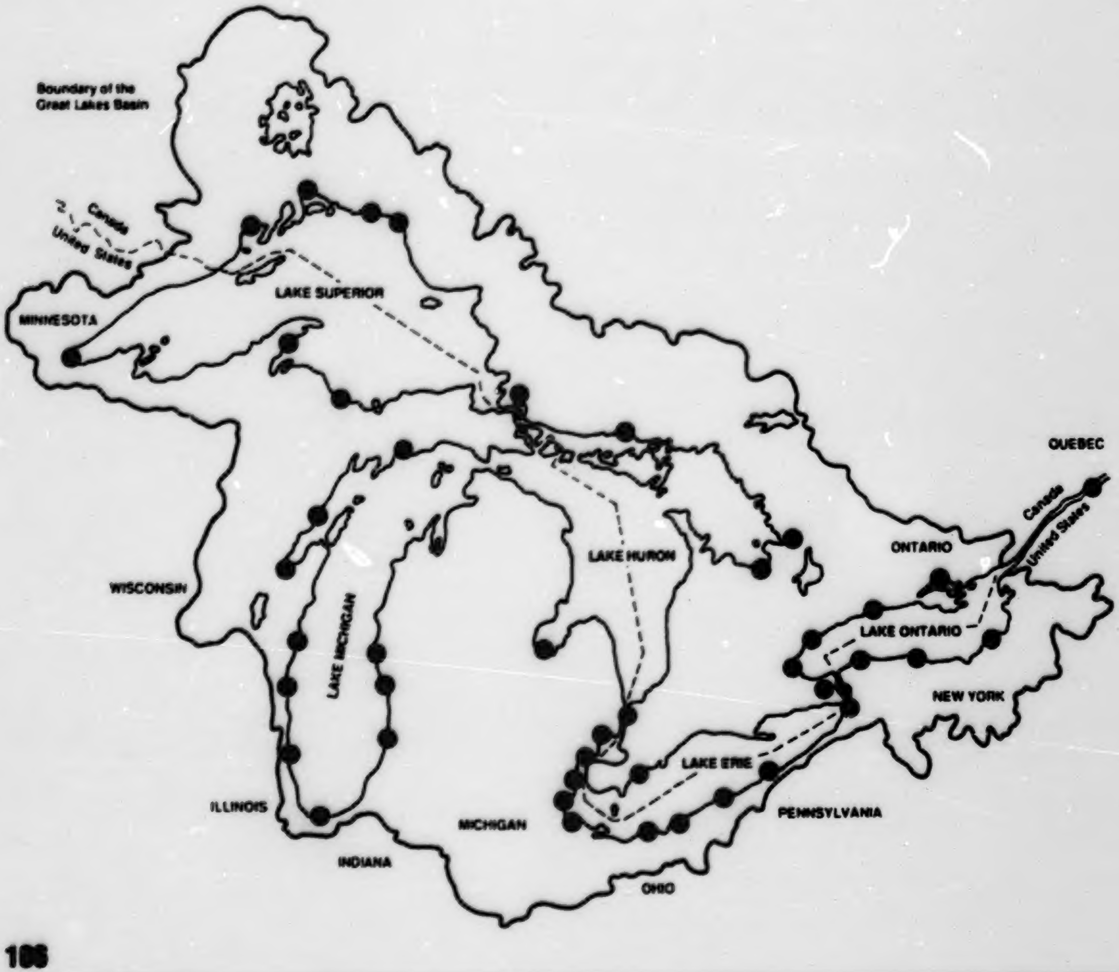
The impairment of beneficial uses that could be sentinel or early warning indicators of relevance to human health

- fish tumours or other deformities;
- bird or animal deformities or reproductive problems;
- loss of fish and wildlife habitat;
- degradation of benthos; and
- degradation of phytoplankton and zooplankton populations.

Seventeen of the AOCs are located in Canada, 12 bordering on Canadian waters and 5 shared with the United States on river systems which connect with the Great Lakes. Canada and Ontario are committed to developing and implementing Remedial Action Plans (RAPs) for these AOCs under the provisions of the Canada-Ontario Agreement Respecting Great Lakes Water Quality (COA). For each of the 17 RAPs, there is a RAP technical team composed of representatives from federal and provincial agencies and a public advisory committee (PAC) involving community stakeholders (industry, business, interest groups, citizens). Overall coordination of Canadian RAPs is achieved through a COA/RAP Steering Committee. Final plans are submitted to the IJC, where progress and implementation of all 43 RAPs are monitored.

FIGURE 8:

Areas of Concern in the Great Lakes Basin


Boundary of the Great Lakes Basin
Canada
United States
LAKE SUPERIOR
MINNESOTA
WISCONSIN
LAKE MICHIGAN
LAKE HURON
QUEBEC
Canada
United States
ONTARIO
LAKE ONTARIO
NEW YORK
LAKE ERIE
PENNSYLVANIA
ILLINOIS
MICHIGAN
INDIANA
OHIO

RAPS are developed in three stages using a comprehensive ecosystem approach. Plans must describe the environmental problems (Stage 1), how they can be cleaned up, by whom and by when (Stage 2), and a final report when clean-up is complete and programs for long-term monitoring are in place (Stage 3).

7.2 RAPs and Human Health

The Great Lakes Water Quality Agreement provides little guidance to RAP teams on ways to address health issues. The IJC and participating agencies have been struggling to develop a standard, practical approach. The issue is complicated, however, by a lack of appropriate scientific or socioeconomic data for assessing human exposure to, or pinpointing health effects caused by, environmental contaminants. In addition, most RAP teams have no representation from the health sector of the community to provide the link between community health expertise and RAPs.

The fact remains, however, that before remedial measures are undertaken, it is as important to have a clear picture of the general health status of the AOC human population as it is for the other members of that ecosystem such as fish and wildlife.

Data on human exposure to contaminants through air, water and soil/sediment, and on quantities and species of fish and wildlife actually consumed by people in the AOC are necessary. In addition, potential "at-risk" populations such as consumers of large amounts of Great Lakes fish, the very young, the elderly, asthmatics and others should be identified. Locations of beaches, marinas, sport fishing areas, etc., should be mapped. Information on the geology of the area, groundwater sources, landfill sites or other potential sources of human contaminant exposure is also important.

One of the main reasons for the development of this handbook was to provide RAP communities with a tool for assessing issues of health and environment. These issues could be public concerns over cancer incidence, for example, as occurred in Wheatley Harbour and St. Lawrence River AOCs, and/or technical issues such as dermal exposure to polycyclic aromatic hydrocarbons (PAHs) in the St. Marys River AOC. The information presented in this handbook will guide you, step by step, through the process of determining exposures to contaminants, identifying data gaps and planning secondary health studies.

APPENDIX A: UNDERSTANDING RATES OF DISEASE

Whether health data are obtained from existing sources or from a community health survey, rates of disease will often be presented or will have to be calculated. Different terms used to express rates of disease are explained below.

Rate of Disease

The *Rate of Disease* is the number of cases relative to a population in a defined time period. The three components of a rate include:

- the absolute number of cases of a disease (numerator);
- the population in which these cases occur (denominator); and
- the time period in which these cases occur (e.g., one year).

$$\text{Rate} = \frac{\text{number of cases within a time period}}{\text{population in which the cases occur}}$$

For example, if 46 cases of leukemia were diagnosed in a city of 387,000 in one year, then the rate of leukemia **for that year** is:

$$\text{Rate} = \frac{46}{387{,}000}$$

$$= 0.000119$$

Rates of disease are often presented in terms of number of cases per 1000, 10,000, 100,000, etc., people. In the above example, the rate (0.000119) can be multiplied by 100,000 to obtain an equivalent rate of 11.9 cases per 100,000 population.

Incidence Rate and Prevalence Rate

The rate just described is the *Incidence Rate*, that is, the number of **newly** diagnosed cases of a disease in a specific time period and population. On the other hand, the *Prevalence Rate* is the number of people in an area who have the disease at any one point in time, **regardless** of when they have been diagnosed.

Crude Rate and Category Specific Rate

The rate of leukemia described above is a *Crude Rate* which does not take into account differences in rates between different ages, gender or ethnic make-up of a population. The rates of disease broken down for specific categories of the population are known as *Category Specific Rates*.

Standardized Mortality (or Morbidity) Ratio (SMR)

In order to make it easier to compare rates of disease (morbidity) and death (mortality) between different populations, *Standardized Mortality Ratios* (SMR) are often calculated. The Standardized Mortality Ratio is defined as the number of events observed in a study population divided by the number that would be expected if the study population had the same specific rates as a standard or comparison population. In Ontario, provincial norms are most often used as the standard population rates. The events in the SMR can be either death (i.e., mortality) or incidence of disease (i.e., morbidity).

$$\textbf{SMR} = \frac{\textbf{Total observed events in a study population}}{\textbf{Total expected events in that population}}$$

If the SMR is greater than 1, it means that more events (i.e., mortality or morbidity) are observed in the study population than would be expected on the basis of rates in the standard population. Conversely, if the ratio is less than 1, fewer events are observed than expected.

SAMPLE CALCULATION OF A STANDARDIZED MORTALITY RATIO FOR LEUKEMIA IN MALES

Four deaths from leukemia have been observed in a male study population of 36,000 over the course of a year, which is equivalent to 11.1 leukemia deaths for a population of 100,000 (4 cases/36,000 = 11.1 cases/100,000). The death rate of the standard male population for leukemia in Ontario is 6 per 100,000 males.

$$\textbf{SMR} = \frac{\textbf{Total observed events in a study population}}{\textbf{Total expected events in that population}}$$

$$= \frac{11.1}{6}$$

$$= 1.85$$

Therefore, the mortality rate from leukemia in the male study population is 1.85 times (or 85%) greater than would be expected if the Ontario standard rate applied to the study population.

Note: *This example comprises fictitious data.*

APPENDIX B: UNDERSTANDING RISK

Risk

In the context of human exposure to environmental contaminants, *Risk* is the probability or likelihood that an adverse health effect (i.e., disease) will occur in a person or group that is exposed to a particular concentration or dose of a hazardous agent. The greater the level of exposure, the higher the risk.

Relative Risk

In assessing the association between an environmental contaminant and disease, a commonly used technique in epidemiological studies is the estimation of the *Relative Risk* of the disease for people who are exposed to the agent, as compared to people who are not exposed. The relative risk is defined as the ratio of the disease incidence rate among exposed people to the disease incidence rate among unexposed people. A disease incidence rate is typically expressed as the number of new cases per year per 100,000 persons (see **Appendix A** for more information on disease incidence rates)

$$\text{Relative Risk} = \frac{\text{Disease Incidence Rate for Exposed Population}}{\text{Disease Incidence Rate for Unexposed Population}}$$

Thomas Rahn

Relative risk is a measure of the strength of association between exposure and disease. A relative risk of 1 corresponds to no association between exposure to a contaminant and disease, that is, exposed people get the disease at the same rate as unexposed people. A relative risk of 2, for example, means that exposed people in the study get the disease at twice the rate observed for unexposed people. On the other hand, a relative risk less than 1 indicates that the rate of disease for the exposed population is less than that for the unexposed population.

SAMPLE CALCULATION OF RELATIVE RISK

Consider a fictitious study comparing the incidence of liver cancer in farmers who use pesticide BRANDX to farmers who do not use this pesticide. The incidence rate of liver cancers among farmers who use the pesticide is 140 per 100,000 and for farmers who do not use the pesticide, 80 per 100,000. The relative risk for farmers who use the pesticide is:

$$\frac{140}{80} = 1.75$$

Therefore, the incidence of liver cancers in farmers who use the pesticide BRANDX is 1.75 times (or 75%) greater than in farmers who do not use the pesticide.

Attributable Risk

When examining the associations between exposure to environmental contaminants and the incidence of disease, it is important to separate the risk of disease that can be attributed to exposure to an agent from the total risk of disease. Therefore, *Attributable Risk* is defined as the incidence rate of disease in exposed individuals that can be attributed to the exposure. This measure is derived by subtracting the disease incidence rate among the unexposed population from the rate among the exposed population. It also assumes that causes other than the one under investigation have had equal effects on the exposed and unexposed groups. These can include diet, smoking, age and heredity.

Attributable Risk = Disease Incidence Rate for Exposed Population − Disease Incidence Rate for Unexposed Population

SAMPLE CALCULATION OF ATTRIBUTABLE RISK

Consider the above fictitious study comparing the incidence of liver cancer in farmers who use pesticide BRANDX to farmers who do not use this pesticide.

In assessing the individual risk of liver cancer attributable to BRANDX pesticide use in farmers, we must subtract out liver cancers that would have occurred even without pesticide use. Only the risk above this baseline value is attributed to the pesticide.

The incidence rate of liver cancers among farmers who use the pesticide is 140 per 100,000 and for farmers who do not use the pesticide, 80 per 100,000. The attributable risk for farmers who use the pesticide is:

$$140 - 80 \quad = \quad 60$$

Therefore, for every 100,000 farmers who use the BRANDX pesticide, 60 cases of liver cancer per year out of a total of 140 cases can be attributed the pesticide itself. The other 80 cases can be attributed to other factors assumed to be equal in both exposed and unexposed groups, such as diet, smoking and heredity.

APPENDIX C: SAMPLE MATERIAL SAFETY DATA SHEET

As mentioned earlier, every facility storing or using a hazardous substance must have a copy of the Material Safety Data Sheet (MSDS) for that substance on file. To give a sense of what kind of information an MSDS contains, a sample MSDS for the chemical 2,4-D follows.

2,4-D is a herbicide whose uses include keeping dandelions and other plant species out of lawns. The use of 2,4-D in park areas has become controversial in some communities because of fears about health and environmental effects.

As is typical for MSDSs, this example contains a good number of technical terms and acronyms. The sections of the MSDS most relevant to an exposure assessment are:

1. Ingredients;
2. Physical Data;
5. Environmental and Disposal Information;
6. Health Hazard Data;
8. Handling Precautions; and
9. Additional Information.

The Ingredients and Health Hazards Data will give you some background information on how toxic the substance is. The ingredients will obviously be helpful only if you recognize the substances listed.

The Physical Data and Additional Information give some clues as to what exposure pathways the substance will likely take. In this case, because 2,4-D decomposes when it boils, has a low vapour pressure and no vapour density, you can rule out the air pathway, except as dust. However, it is soluble in water and could conceivably be found in solid form on food or in the soil, if it has been spilled. From the Additional Information you may get a better sense of where and how the substance is meant to be used, and thus clues on where it will turn up in the environment. The section on Environmental and Disposal Information and on Handling Procedures allow you to evaluate whether the substance is being handled properly. If the instructions are not being followed, then it is more likely that this substance will be an environmental contaminant of concern.

If an MSDS leaves you baffled, the Canadian Centre for Occupational Health and Safety is the best source of information on MSDSs. They also provide, at a small charge, the following publications on MSDSs:

Material Safety Data Sheets: A basic guide for users; and
Material Safety Data Sheets: An explanation of common terms.

These publications can be ordered from the CCOHS Inquiry Service: 1-800-263-8466.

Alternatively, try asking a toxicologist for assistance.

MATERIAL SAFETY DATA SHEET (MSDS) FOR 2,4-D

Generic Chemical Company Phone: 123-456-7890
Product Code: 12345
PRODUCT NAME: 2,4-DICHLOROPHENOXYACETIC ACID, FLAKE
Effective Date: 06/30/92 Date Printed: 05/25/93 MSDS: 001

1. **INGREDIENTS: (% w/w, unless otherwise noted)**

2,4-Dichlorophenoxyacetic acid, min.	CAS# 000094-75-7	97.0%
4-Chlorophenoxyacetic acid, max.	CAS# 000122-88-3	1%
2,6-Dichlorophenoxyacetic acid, max.	CAS# 006575-24-2	1%

2. **PHYSICAL DATA:**

BOILING POINT: Decomposes
VAPOUR PRESSURE: (mmHG @ 20C) very low
VAPOUR DENSITY: Not applicable
SOLUBILITY IN WATER: 0.09gm/100gm
SPECIFIC GRAVITY: Powder 1.416 (35C)
APPEARANCE: White powder
ODOUR: Phenolic odour

3. **FIRE AND EXPLOSION HAZARD DATA:**

FLASH POINT: None
METHOD USED: TCC, TOC
FLAMMABLE LIMITS:
LFL: Not applicable. UFL: Not applicable.
EXTINGUISHING MEDIA: Water fog, foam, CO_2, dry chemical.
FIRE AND EXPLOSION HAZARDS: Noxious fumes produced when exposed to fire conditions.
FIRE-FIGHTING EQUIPMENT: Wear positive-pressure self-contained breathing apparatus.

4. **REACTIVITY DATA:**

STABILITY: (CONDITIONS TO AVOID) Decomposes above 302F (150C) when dry.
INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Alkaline or oxidizing materials.
HAZARDOUS DECOMPOSITION PRODUCTS: HCl under fire conditions.
HAZARDOUS POLYMERIZATION: Will not occur.

5. **ENVIRONMENTAL AND DISPOSAL INFORMATION:**

ACTION TO TAKE FOR SPILLS/LEAKS: Sweep up spills.
DISPOSAL METHOD: If wastes cannot be disposed of by use according to label instructions, contact your provincial pesticide or environmental control agency, or the hazardous waste representative for guidance.

6. HEALTH HAZARD DATA:

EYE: May cause pain. May cause severe irritation with corneal injury. Effects may be slow to heal. Dust may irritate eyes.

SKIN CONTACT: Prolonged or repeated exposure may cause skin irritation.

SKIN ABSORPTION: A single prolonged skin exposure is not likely to result in the material being absorbed through the skin in harmful amounts. Repeated skin exposure may result in absorption of harmful amounts. The LD_{50} for skin absorption in rabbits is 1400 to >2000 mg/kg.

INGESTION: Single dose oral toxicity is moderate. The oral LD_{50} for rats is 375 to >1000 mg/kg. Amounts ingested incidental to industrial handling are not likely to cause injury; however, ingestion of larger amounts may cause injury. Ingestion may cause gastrointestinal irritation or ulceration.

INHALATION: Vapours are unlikely due to physical properties.

SYSTEMIC AND OTHER EFFECTS: Excessive exposure may cause liver, kidney, gastrointestinal and muscular effects. Signs and symptoms of excessive exposure may be nausea and/or diarrhea. Various animal cancer tests have shown no reliably positive association between 2,4-D exposure and cancer. Epidemiology studies on herbicide use have been both positive and negative with the majority being negative. Birth defects are unlikely. Exposures having no effect on the mother should have no effects on the fetus. Did not cause birth defects in animals; other effects were seen in the fetus only at doses which caused toxic effects to the mother. Excessive dietary levels caused toxic effects (weight and viability reduction) in rats on a reproduction test. Results of mutagenicity tests in animals have been inconclusive. Has been shown to be negative in some in vitro (test tube) mutagenicity tests and positive in others.

7. FIRST AID:

EYES: Irrigate with flowing water immediately and continuously for 15 minutes. Consult medical personnel.

SKIN: Wash off in flowing water or shower.

INGESTION: If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Seek medical attention immediately.

INHALATION: Remove to fresh air if effects occur. Consult a physician.

NOTE TO PHYSICIAN: No specific antidote. Supportive care. Treatment based on judgement of the physician in response to reactions of the patient.

8. HANDLING PRECAUTIONS:

EXPOSURE GUIDELINE(S): ACGIH TLV and OSHA PEL are 10mg/m^3.

VENTILATION: Good general ventilation should be sufficient for most conditions. Local exhaust ventilation may be necessary for some operations.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. When respiratory protection is required for certain operations, use an approved air-purifying respirator.

SKIN PROTECTION: Wear clean, long-sleeved, body-covering clothing. Use impervious gloves when prolonged or repeated contact could occur.

EYE PROTECTION: Use chemical goggles.

9. ADDITIONAL INFORMATION

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: See label. Keep out of reach of children. Do not swallow. Avoid eye and skin contact. Do not store near seeds, fertilizers, insecticides or fungicides.

APPENDIX D: UNITS OF MEASUREMENT

Units of measurement can often be quite confusing, especially as each thing being measured seems to use different units. In this section, the various units and how to convert them from one to another will be described.

1. Chemicals

In *liquids* such as water, levels or concentrations of contaminants are most commonly expressed in milligrams per litre (mg/L) or micrograms per litre (µg/L). One milligram equals one thousand micrograms. In *soil, food and other solids*, contaminant levels are usually expressed in milligrams per kilogram (mg/kg). Concentrations of chemicals and dust in *air* are usually expressed as milligrams or micrograms per cubic metre (mg/m^3, µg/m^3). Occasionally, the units for chemical concentrations in water, soil, food and air are expressed in parts per million (ppm), parts per billion (ppb), parts per trillion (ppt) or parts per quadrillion (ppq). The relationship of the various expressions of concentration are shown below.

BASIC UNITS

g (gram)	µg (microgram) = 10^{-6} gram
kg (kilogram) = 10^3 gram	ng (nanogram) = 10^{-9} gram
mg (milligram) = 10^{-3} gram	pg (picogram) = 10^{-12} gram

SOIL AND WATER

Metric Units in Liquids	Equivalent in Parts per Unit ppm	 ppb	 ppt	 ppq	Metric Units in Solids
1 g/L	10^3	10^6	10^9	10^{12}	1 g/kg
1 mg/L	1	10^3	10^6	10^9	1 mg/kg
1 µg/L	10^{-3}	1	10^3	10^6	1 µg/kg
1 ng/L	10^{-6}	10^{-3}	1	10^3	1 ng/kg
1 pg/L	10^{-9}	10^{-6}	10^{-3}	1	1 pg/kg

AIR

Converting from ppm in Air to its Equivalent in $\mu g/m^3$

Converting air contaminant values from ppm to $\mu g/m^3$ is not as straightforward as similar conversions in water or soil. In this case, the conversion is dependent on the atomic molecular weight of the contaminant. Atomic weights are found in most chemistry textbooks. To convert from ppm to $\mu g/m^3$ in air, the following equation is used:

Contaminant Concentration ($\mu g/m^3$) = Contaminant concentration (ppm) x Molecular Weight of the Contaminant x 40.9

EXAMPLE: Convert the pollutant ozone, at 0.08 ppm in air, to its equivalent in $\mu g/m^3$. The molecular weight of ozone is 48.

Contaminant Concentration ($\mu g/m^3$) = 0.08 ppm x 48 x 40.9

= 157 $\mu g/m^3$

157 $\mu g/m^3$ ozone is equivalent to 0.08 ppm ozone.

2. Microorganisms

Microorganisms, including bacteria, viruses and protozoa, are usually measured by the number of organisms present in a given volume. For example,

100 organisms/100 millilitres (mL) and

100 organisms/cubic centimetre (cm^3)

3. Radiation

Different characteristics of radiation can be measured as it travels from its source into living organisms. The three characteristics described below are: the activity, the absorbed dose and the equivalent dose. For each characteristic of radiation, at least two different units exist. These different units are simply older and newer descriptions of the same thing, just as, for example, feet and metres both measure distance.

RADIOLOGICAL UNITS

Quantity	Metric Unit	Symbol	Old Unit	Symbol	Relationship
Activity	becquerel	*Bq*	curie	*Ci*	1 *Ci* = 3.7 x 10^{10} *Bq*
Absorbed dose	gray	*Gy*	rad	*rad*	1 *rad* = 0.01 *Gy*
Dose equivalent	sievert	*Sv*	rem	*rem*	1 *rem* = 0.01 *Sv*

Activity

Radioactive elements (radionuclides) decay or break down into lighter substances. As they decay, they emit energy which is called ionizing radiation. The more decay, the more radiation is produced. The energy released during radioactive decay is in the form of alpha, beta or gamma radiation. The activity of a radionuclide is a measure of its rate of decay. The becquerel (*Bq*) is the International System (S.I.) unit for measuring this activity. The older unit of measurement is the curie (*Ci*). One curie equals 3.7×10^{10} becquerels.

Absorbed Dose

When ionizing energy from a radioactive substance moves into a living organism, energy is given off to the cells of the organism. That energy damages the cells and interferes with their functioning. The damage to cells depends on the amount of energy given off per kilogram of living tissue. This amount is the absorbed dose and the S.I. unit is the gray (*Gy*). One gray equals one joule (J) of energy absorbed per kilogram of living tissue. The older unit for the absorbed dose is the *rad* (100 *rad* = 1 *Gy*).

Equivalent Dose

Not all absorbed doses of radiation are equal in their ability to cause damage to living cells. This is because radioactivity produces different kinds of energy, such as alpha, beta and gamma. The damage caused by each radiation type is directly related to how quickly each type gives off its energy as it travels through living tissue. Alpha radiation, for example, causes the most damage because it loses its energy very quickly along its path. On the other extreme, gamma radiation causes the least damage because it loses little of its energy.

To give a more accurate picture of the damage caused by an absorbed dose of radiation, a new unit of measurement is calculated: the equivalent dose. The equivalent dose is directly related to the absorbed dose, but takes into account the type of radiation involved. To calculate equivalent dose, the absorbed dose for each radiation type is multiplied by a factor that reflects its ability to do damage. This factor, called the *radiation weighting factor*, ranges from 1 for beta radiation to 20 for alpha radiation.

COMPARISON OF ABSORBED AND EQUIVALENT DOSE

Radiation Type	Absorbed Dose	Equivalent Dose
Beta radiation	1 *Gy*	1 *Sv*
Alpha radiation	1 *Gy*	20 *Sv*

The S.I. unit for the equivalent dose is the sievert (Sv). One sievert is equal to one joule of energy absorbed per kilogram of body weight (J/kg). The older unit of measurement for the equivalent dose is the *rem* (100 *rem* = 1 Sv).

Further Complications:

Does the equivalent dose imply that alpha radiation is always more dangerous than beta or gamma radiation? The answer is not that simple. Gamma radiation can be a greater hazard to health because it travels furthest into the body. Alpha radiation is stopped by the skin. It becomes a hazard only when the source of the alpha radiation has been swallowed or breathed into the body. Gamma radiation, on the other hand, is a hazard from any kind of source, whether inside or outside the body.

To complicate matters further, some body tissues can be damaged more easily by radiation than others. For example, the risk of fatal lung cancer is greater than the risk of fatal bone cancer, for the same equivalent dose. In other words, the effect of an equivalent dose depends on what part of the body is exposed. To account for these differences, scientists have developed another factor, called the *tissue weighting factor*. By multiplying the equivalent dose by this factor for each organ in the body, and then adding the results of all the organs, a new quantity can be calculated: the *effective dose*. The effective dose gives an overall measure of the risk to health of any type of radiation, no matter which parts of the body are exposed, and regardless of whether the source is inside or outside the body.

Attributable Risk

Attributable risk is defined as the rate of disease in exposed individuals that can be attributed to the exposure. This measure is derived by subtracting the disease rate among the unexposed population from the rate among the exposed population. It also assumes that causes other than the one under investigation have had equal effects on the exposed and unexposed groups.

Bioaccumulation

Some pollutants are not excreted quickly, but rather are stored in parts of the body for long periods of time. Total pollutants in the body (the "body burden") may build up if the organism is exposed to the substance for a long period of time.

Biomagnification

Pollutants "biomagnify" when they build up to higher levels as they move through the food chain. For example, when pollutants in plants are passed on to animals feeding on the plants, the animals may be exposed to higher levels because the plants have collected and concentrated pollutants, and the animals eat many plants.

Carcinogen

A substance (e.g., a chemical) or an agent (e.g., ionizing radiation) that causes cancer.

Congener

A different configuration or mixture of a single chemical where some of the atoms occupy different positions in the molecule.

Contaminant

A substance foreign to a natural system or present at unnatural concentrations.

Control group

In an experimental or follow-up study, the control group comprises subjects being observed who have not been exposed to the contaminant being studied, for comparison with exposed groups. In a case-control study, the control group is made up of subjects without the disease under study, for comparison with a group that has the disease.

DDT

An insecticide, also called dichlorodiphenyl trichloroethane. DDT can break down to DDE (dichlorodiphenyl dichloroethylene), which is very persistent in the environment.

Demography

The study of populations, especially with reference to size and population density, fertility, mortality, growth, age distribution, migration and vital statistics, and the interaction of all these with social and economic conditions.

Detection limit

The lowest concentration of a substance that can be detected with certainty by the measuring technique being used.

Dioxin

A group of about 75 chemicals, also called polychlorinated dibenzodioxins (PCDDs). The most toxic is 2,3,4,5-TCDD (tetrachlorinated dibenzodioxin).

Disease cluster

A series of cases of disease or other health effects that all occur around the same time or in the same place or both.

Dose-response curve

A mathematical relationship between exposure to a toxic chemical and some health effect ("end point"). Often, higher doses will produce larger numbers of adverse affects or more severe reactions. For example, the more alcoholic beverage a person consumes, the more likely the person is to show signs of intoxication. Since there is a mathematical relationship between the amount of exposure (the "dose") and the effects observed (the "response"), the relationship can be shown on a graph or "curve."

Epidemiology

The science that studies statistical relationships between patterns of disease and the occurrence of possible causing or contributing factors.

Excess risk

An increased risk of disease above the background rate.

Exposure

Exposure is any contact between a substance and an individual who has touched, breathed dust or fumes, or swallowed material or liquid from a contaminated source. It is quantified as the amount of the substance, that can be absorbed, available at the exchange boundaries of the organism (e.g., skin, lungs, digestive tract).

Exposure assessment

Measurement or estimation of the magnitude, frequency, duration and route of exposure of individuals or populations to substances in the environment.

Exposure pathway

The pathway a contaminant may take to reach humans or other living organisms. Exposure pathways include all the elements that link the source of a contaminant to the exposure route (ingestion, inhalation, skin contact) by which the contaminant enters the body.

Exposure route

The means by which contaminants enter the body, such as by ingestion (swallowing), by inhalation (breathing) and by skin contact (touching).

Food web

A food web consists of different species of plants and animals that are dependent on each other for food. It usually contains green plants (primary producers), herbivores that eat the plants and one or more level of carnivorous or predatory species. Humans are at the top of many food webs.

Guideline

A recommended limit for a substance or an agent intended to protect human health or the environment. It is not legally enforceable.

Half-life

The amount of time required for half of a particular pollutant to degrade (change to another chemical form) in the environment, so that only half of the amount of the original pollutant is left in the environment.

Hepatic

To do with the liver.

Incidence

The number of new cases of a disease occurring in a defined population, within a specified period of time. It is frequently presented as the number of new cases per 1,000 or 100,000 per year. The incidence rate can provide a direct estimate of the risk of developing a disease during a specified time period.

LD_{50}

The LD_{50} is the dose of a substance fed to rats (unless otherwise specified) that will cause death in 50% of the test animals. LD stands for lethal dose.

Latency period

The period of time between exposure to a disease-causing agent and the appearance or manifestations of the disease.

Mutagen

A substance or agent which can alter the genetic material (DNA or RNA), resulting in changes that may be inherited.

Objective

A preferred or desired level of a substance or an agent in the environment, often zero or the detection limit.

PCBs

A group of 209 chemical compounds, also called polychlorinated biphenyls, made up of carbon, hydrogen and chlorine.

Persistent

A pollutant that takes a long time to break down or be rendered harmless in the environment. Under the Great Lakes Water Quality Agreement, a persistent pollutant is one with a half-life of eight weeks or longer.

Prevalence

The number of existing cases of a given disease or other condition in a given population at a designated point in time.

Radionuclide

An unstable nuclide (nucleus of an atom) that undergoes spontaneous radioactive decay, emitting radiation as it does so, and changing eventually from one element into another.

Relative risk

Relative risk is a measure of the strength of association between exposure and disease. The relative risk is defined as the ratio of the disease rate among exposed people to the disease incidence rate among unexposed people.

Renal

To do with the kidney.

Risk

Risk is the probability or likelihood that an adverse health effect (i.e., disease) will occur in a person or group that is exposed to a particular concentration or dose of a hazardous agent.

Risk assessment

Techniques for systematically measuring and estimating the likely health impacts and other results of releasing or discharging specified amounts of pollutants.

Risk management

Making decisions with regard to release of a pollutant on the issue of how much risk, and to whom, will be considered acceptable.

Standard

A legally enforceable limit for a substance or an agent intended to protect human health or the environment. Exceeding the standard could result in unacceptable harm to whatever it is intended to protect.

Standardized Mortality (or Morbidity) Ratio

The Standardized Mortality Ratio (SMR) is the number of deaths (or disease) observed in a population divided by the number that would be expected in a standard or comparison population. The events in the SMR can be either death (i.e. mortality) or incidence of disease (i.e., morbidity).

Teratogen

A substance or agent which can cause effects (e.g., birth defects) in the offspring of exposed adults.

Tolerable Daily Intake (TDI)

The Tolerable Daily Intake is an estimate of the quantity of a chemical that humans can consume every day for their whole life without threatening their health. It is usually expressed in milligrams of chemical per kilogram of body weight per day (mg/kg/day).

Toxic substance

A substance capable of causing harm to humans, animals or other living things at some level of exposure. In common usage, the term refers to chemical substances that are capable of causing harm at very low levels of exposure, while providing little or no benefit to the organism in question.

Toxicology

A science that studies the effects of poisons on humans, animals or other organisms.

Investigating Human Exposure to
Contaminants in the Environment:

A Community Handbook

PART C: INFORMATION SOURCES

1. SELECTED BIBLIOGRAPHY

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1.2 Environmental Contaminants and Human Health - General

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1989. *Aluminum and Human Health;*
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Health Canada - Publications
Mailstop 0913 A
Brooke Claxton Building
Tunney's Pasture
Ottawa, Ontario K1A 0K9
Tel: (613) 954-5995

1.3 Assessing Human Exposure

Agency for Toxic Substances and Diseases Registry (ATSDR). 1990. *Clues to Unravelling the Association Between Illness and Environmental Exposure*. Continuing Education Institute, American Public Health Association.

Agency for Toxic Substances and Diseases Registry (ATSDR). 1992. *Public Health Assessment Guidance Manual*. Lewis Publishers, Michigan.

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Legator M.S. and Strawn S.F. (eds.). 1993. *Chemical Alert! A Community Action Handbook*. University of Texas Press, Austin.

2. RESOURCES AND CONTACTS

2.1 Federal Government

Atmospheric Environment Service
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
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Health Statistics Division
Statistics Canada
R.H. Coats Building
Tunney's Pasture
Ottawa, Ontario K1A 0T6
Tel: (613) 951-1746 (Information Enquiries)

Canadian Wildlife Service
Environment Canada
Place Vincent Massey
351 St Joseph Blvd.
Hull, Quebec K1A 0H3
Tel: (819) 997-1095

Environmental Radiation Hazards Division
Radiation Protection Bureau
Health Canada
775 Brookfield Road, Confederation Heights
Ottawa, Ontario K1A 1C1
Tel: (613) 954-6671

Great Lakes Environment Office
Conservation and Protection
Environment Canada
25 St. Clair Avenue East, Suite 600
Toronto, Ontario M4T 1M2
Tel: (416) 973-8632

Great Lakes Health Effects Program
Health Canada
Main Building, Room 1108
Tunney's Pasture, 0301 A1
Ottawa, Ontario K1A 0K9
Tel: (613) 957-1876

Food Directorate
Health Canada
Health Protection Building
Tunney's Pasture
Ottawa, Ontario K1A 0L2
Tel: (613) 957-1821

Laboratory Centre for Disease Control
Health Canada
LCDC Building
Tunney's Pasture
Ottawa, Ontario K1A 0L2
Tel: (613) 957-0316

Monitoring and Criteria Division (Hazardous Wastes)
Bureau of Chemical Hazards
Health Canada
Room 126, Environmental Health Centre
Tunney's Pasture
Ottawa, Ontario K1A 0L2
Tel: (613) 957-3128

Pesticides Information Division
Agriculture and Agri-Food Canada
59 Camelot Drive
Nepean, Ontario K1A 0Y9
Tel: 1-800-267-6315 (Pesticides Information Call-Line)

Workplace Hazardous Materials Information Systems (WHMIS)
Product Safety Bureau
Health Canada
17th floor, Zone 2
Place du Portage, Phase 1
50 Victoria Street
Hull, Quebec K1A 0C9
Tel: (819) 953-2035

2.2 Provincial Government (Ontario)

Environmental Health and Toxicology Unit
Ontario Ministry of Health
5700 Yonge Street, 8th floor
North York, Ontario M2M 4K2
Tel: (416) 327-7427

Great Lakes Section
Ontario Ministry of Environment and Energy
125 Resources Road
Etobicoke, Ontario M9P 3V6
Tel: (416) 235-6222

Hazardous Contaminants Coordination Branch
Ontario Ministry of Environment and Energy
135 St. Clair Avenue West
Toronto, Ontario M4V 1P5
Tel: (416) 323-5095

Ontario Ministry of Environment and Energy
Public Inquiries Centre
135 St. Clair Avenue West, 1st floor
Toronto, Ontario M4V 1P5
Tel: (416) 323-4231 or 1-800-565-4923

Ontario Ministry of Natural Resources
Public Information Centre
900 Bay Street, Room 1-M73
McDonald Block
Toronto, Ontario M7A 2C1
Tel: (416) 314-2000

2.3 Municipal Government

Local Commissioner of Planning and Public Works

Address: ______________________________
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Tel: ______________________________

Address: ______________________________
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Tel: ______________________________

Address: ______________________________
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Tel: ______________________________

Address: ______________________________
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Tel: ______________________________

Local Environment Office

Address: ______________________ Address: ______________________

Tel: ______________________ Tel: ______________________

Local Sewage Treatment Plant

Address: ______________________ Address: ______________________

Tel: ______________________ Tel: ______________________

Address: ______________________ Address: ______________________

Tel: ______________________ Tel: ______________________

Other Local Contacts

Address: ______________________ Address: ______________________

Tel: ______________________ Tel: ______________________

Address: ______________________ Address: ______________________

Tel: ______________________ Tel: ______________________

2.4 Academic Institutions

Institute of Environment and Health

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   Hamilton, Ontario L8S 4K1
   Tel: (905) 525-9140 x 27344
2. University of Toronto
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   Toronto, Ontario M5S 1A4
   Tel: (416) 978-6925

Queen's University
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University of Ottawa
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University of Western Ontario
Faculty of Medicine
Department of Family Medicine
Kresge Building, Room K101
London, Ontario N6A 5C1
Tel: (519) 661-2037

York University
Faculty of Environmental Studies
355 Lumbers Building
4700 Keele Street
North York, Ontario M3J 1P3
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2.5 Agencies and Associations

Agency for Toxic Substances and Diseases Registry (USA)
Department of Health and Human Services
1600 Clifton Road
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Tel: (404) 639-6206

Canadian Centre for Occupational Health and Safety
250 Main Street East
Hamilton, Ontario L8N 1H6
Tel: (1-800) 263-8466

Canadian Environmental Law Association
517 College Street, Suite 401
Toronto, Ontario M6G 4A2
Tel: (416) 960-2284

Canadian Institute for Health Information
250 Ferrand Drive, 5th floor
Box 3900
Don Mills, Ontario M3C 2T9
Tel: (416) 429-0464

Canadian Institute of Public
Health Inspectors
38 Auriga Drive, Suite 201
Nepean, Ontario K2E 8A5
Tel: (613) 224-7568

Canadian Public Health Association
1565 Carling Avenue, Suite 400
Ottawa, Ontario K1Z 8R1
Tel: (613) 725-3769

Great Lakes Pollution Prevention Centre
265 North Front Street, Suite 112
Sarnia, Ontario N7T 7X1
Tel: (519) 337-3423 or 1-800-667-9790

International Commission on Radiological
Protection (ICRP)
The documents of ICRP are published as the
Annals of ICRP and are available from:
Review Journals
Pergamon Press plc
Headington Hill Hall
Oxford, OX3 0BW U.K.
Tel: 0865 794141

International Institute of Concern for Public
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710 - 264 Queen's Quay West
Toronto, Ontario M5J 1B5
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International Joint Commission
Great Lakes Regional Office
100 Ouellette Avenue, 8th floor
Windsor, Ontario N9A 6T3
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Toronto, Ontario M5A 4L3
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National Radiation Protection Board (NRPB)
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National Technical Information Service (U.S.A.)
U.S. Department of Commerce
5285 Port Royal Road
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Ontario Cancer Treatment and Research Foundation
620 University Avenue, 15th floor
Toronto, Ontario M5G 2L7
Tel: (416) 971-9800

Ontario College of Family Physicians
Standing Committee on Environment and Health
2630 Skymark Avenue
Mississauga, Ontario L4W 5A4
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Ontario Public Health Association
468 Queen Street East, Suite 202
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2.6 Environmental Groups and Networks

Canadian Environmental Network
P.O. Box 1289, Station B
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Tel: (613) 563-2078

Canadian Network for Environmental Educators and Communicators (EECOM)
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Great Lakes United
76 University Avenue West
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Greenpeace
185 Spadina Avenue, 6th floor
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Ontario Environment Network
27 Douglas Street
Guelph, Ontario N1H 2S7
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Ontario Healthy Communities Coalition
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Ontario Public Interest Research Group (OPIRG)
455 Spadina Avenue, Room 201
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Jackfish Bay	Jim Murphy Ministry of Environment and Energy Thunder Bay District Office 435 James Street South, Suite 331 P.O. Box 5000 Thunder Bay, Ontario P7E 6E3 Tel: (807) 475-1689
Nipigon Bay	Ken Cullis Ministry of Natural Resources North Central Region Lake Superior RAP Office 1194 Dawson Road RR #12, S8, C16 Thunder Bay, Ontario P7B 5E3 Tel: (807) 768-1826

Spanish River	Jan Linquist Ministry of Environment and Energy Northeastern Region Sudbury Regional Office 199 Larch Street, 11th floor Sudbury, Ontario P3E 5P9 Tel: (705) 670-3238
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Wheatley Harbour	Doug Huber Ministry of Environment and Energy Southwestern Region London Regional Office 985 Adelaide Street South London, Ontario N6E 1V3 Tel: (519) 661-2261
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Bay of Quinte - St. Lawrence River	Rick Kirk Ministry of Environment and Energy Kingston Regional Office 133 Dalton Avenue, P.O. Box 820 Kingston, Ontario K7L 4X6 Tel: (613) 549-4000

2.8 Public Health Units - Ontario

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99 Foster Drive
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Brant County Health Unit
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194 Terrace Hill Street
Brantford, Ontario N3R 1G7
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Bruce-Grey-Owen Sound Health Unit
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Owen Sound, Ontario N4K 4K5
Tel: (519) 376-9420

Durham Regional Health Unit
Medical Officer of Health
Suite 210
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Whitby, Ontario L1N 2L1
Tel: (905) 723-8521

Eastern Ontario Health Unit
Medical Officer of Health
1000 Pitt Street
Cornwall, Ontario K6J 5T1
Tel: (613) 933-1375

East York Health Unit
East York Civic Centre
850 Coxwell Avenue
East York, Ontario M4C 5R1
Tel: (416) 461-8136

Elgin-St. Thomas Health Unit
Medical Officer of Health
99 Edward Street
St. Thomas, Ontario N5P 1Y8
Tel: (519) 631-9900

Etobicoke Health Unit (City of)
Medical Officer of Health
Etobicoke City Hall
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Etobicoke, Ontario M9C 2Y2
Tel: (416) 394-8300

Haldimand-Norfolk Regional Health Unit
Medical Officer of Health
365 West Street, P.O. Box 247
Simcoe, Ontario N3Y 4L1
Tel: (519) 426-6170

Haliburton, Kawartha, Pine Ridge
District Health Unit
Medical Officer of Health
200 Rose Glen Road
Port Hope, Ontario L1A 3V6
Tel: (905) 885-9100

Halton Regional Health Department
Medical Officer of Health
1151 Bronte Road
Oakville, Ontario L6M 3L1
Tel: (905) 825-6060

Hamilton-Wentworth Regional Department of
Public Health Services
Medical Officer of Health
25 Main Street West, P.O. Box 897
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Unit
Medical Officer of Health
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Huron County Health Unit
Medical Officer of Health
Huronview Building
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Clinton, Ontario NOM 1LO
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Kent-Chatham Health Unit
Medical Officer of Health
435 Grand Avenue West
P.O. Box 1136
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Kingston, Frontenac and Lennox and
Addington Health Unit
Medical Officer of Health
221 Portsmouth Avenue
Kingston, Ontario K7M 1V5
Tel: (613) 549-1232

Lambton Health Unit (Sarnia)
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Leeds, Grenville and Lanark District
Health Unit
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Middlesex-London Health Unit
Medical Officer of Health
50 King Street
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Muskoka-Parry Sound Health Unit
Medical Officer of Health
10 Pine Street
Bracebridge, Ontario P1L 1N3
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Niagara Regional Area Health Unit
Medical Officer of Health
573 Glenridge Avenue
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Tel: (905) 688-3762

North Bay and District Health Unit
Medical Officer of Health
101 McIntyre Street West, P.O. Box 450
North Bay, Ontario P1B 8J1
Tel: (705) 474-1400

North York Health Unit (City of)
Medical Officer of Health
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North York, Ontario M2N 5V7
Tel: (416) 395-7700

Northwestern Health Unit
Medical Officer of Health
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Ottawa-Carleton Regional Health Unit
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Peel Regional Health Unit
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Medical Officer of Health
653 West Gore Street
Stratford, Ontario N5A 1L4
Tel: (519) 271-7600

Peterborough County-City Health Unit
Medical Officer of Health
10 Hospital Drive
Peterborough, Ontario K9J 8M1
Tel: (705) 743-1000

Porcupine Health Unit
Medical Officer of Health
169 Pine Street South
P.O. Box 2012
Timmins, Ontario P4N 8B7
Tel: (705) 267-1181

Renfrew County and District Health Unit
Medical Officer of Health
7 International Drive
Pembroke, Ontario K8A 6W5
Tel: (613) 732-3629

Scarborough Health Department (City of)
Medical Officer of Health
160 Borough Drive
Scarborough, Ontario M1P 4N8
Tel: (416) 396-7454

Simcoe County District Health Unit
Medical Officer of Health
15 Sperling Drive
Barrie, Ontario L4M 6K9
Tel: (705) 721-7330

Sudbury and District Health Unit
Medical Officer of Health
1300 Paris Crescent
Sudbury, Ontario P3E 3A3
Tel: (705) 522-9200

Thunder Bay District Health Unit
Medical Officer of Health
999 Balmoral Street
Thunder Bay, Ontario P7B 6E7
Tel: (807) 625-5900

Timiskaming Health Unit
Medical Officer of Health
221 Whitewood Avenue
P.O. Box 1240
New Liskeard, Ontario P0J 1P0
Tel: (705) 647-4305

Toronto Health Unit (City of)
Medical Officer of Health
7th floor, East Tower
100 Queen Street West
Toronto, Ontario M5H 2N2
Tel: (416) 392-7401

Waterloo Health Unit
Medical Officer of Health
99 Regina Street South
Waterloo, Ontario N2J 4V3
Tel: (519) 883-2000

Wellington-Dufferin-Guelph Health Unit
Medical Officer of Health
205 Queen Street East
Fergus, Ontario N9M 1T2
Tel: (519) 843-2460

Windsor-Essex County Health Unit
Medical Officer of Health
1005 Ouellette Avenue
Windsor, Ontario N9A 4J8
Tel: (519) 258-2146

York Health Unit (City of)
Medical Officer of Health
2700 Eglinton Avenue West
Toronto, Ontario M6M 1V1
Tel: (416) 394-2436

York Regional Health Department
Medical Officer of Health
17250 Yonge Street
P.O. Box 147
Newmarket, Ontario L3Y 6Z1
Tel: (905) 895-4511

3. ON-LINE DATABASES

These databases are on computer. To be able to use them, you will need a computer that can communicate with the main database computer. Some public libraries and most university libraries have the necessary equipment and connections to search at least some of these databases for you. For the very scientific databases, the university libraries are better able to handle your information needs. If they cannot do the search, librarians can usually find out who can. For assistance with health statistics databases, try the Medical Officer of Health and the Ontario Ministry of Health.

Most searches will cost money. The more specific you can be about the information you need, the shorter the search and the lower the cost. Again, librarians usually have good ideas on how to reduce your costs.

Data Base Name	Description
Biosis Previews	Contains citations from Biological Abstracts.
CAB Abstracts	A comprehensive file of agricultural and biological information.
CA Search	Contains bibliographic data, keyword phrases and index entries for all documents covered by the Chemical Abstracts Services.
CESARS	The Chemical Evaluation Search and Retrieval System is jointly produced by the Michigan Department of Natural Resources and the Ontario Ministry of Environment and Energy. It contains toxicological data on approximately 250 chemicals with up to 120 data items on each, covering physical and chemical properties, toxicity, carcinogenicity, mutagenicity, teratogenicity and environmental fate.
Chemical Safety Newsbase	Information on the hazardous and potentially hazardous effects of chemicals and processes encountered by workers in industry and laboratories. It also covers microbiological and radiation hazards encountered in the workplace.
CRIS/USDA	Information on U.S. federal- and state-supported research in agriculture, food and nutrition, forestry and related fields.
Drug Information Fulltext	Information on stability, chemistry and phamacokinetics of drugs, as well as on their action, use, dosage and administration. The file also covers compatibility and interactions of drugs and cautions of use.

Data Base Name	Description
EiCompendex Plus	Contains abstracts from the world's significant literature of engineering and technology.
EMBASE	Contains abstracts and citations of articles on human medicine and drugs.
Enviroline	Contains index and abstract coverage of literature on all aspects of the environment.
Environmental Bibliography	Covers fields of general human ecology, atmospheric studies, energy, land resources, water resources, nutrition and health.
International Pharmaceutical Abstracts	Information on all phases of development and use of drugs and on professional pharmaceutical practice.
INIS	The International Nuclear Information System contains more than 1.2 million citations to the literature on the peaceful applications of nuclear science, including medical aspects. Topics include medicine, health, safety and environment, and industrial applications of radioisotopes and radiation.
IRIS	The Integrated Risk Information System registry contains toxicological and regulatory information on more than 400 chemicals with more added to the database each year.
MEDLINE/MEDLARS	Covers articles on every aspect of biomedicine.
Pollution Abstracts	References to environment-related literature on pollution, its sources and its control.
NIOSHTIC	Covers all aspects of occupational safety and health.
NTIS	Contains results of U.S. government-sponsored research, development and engineering.
RIEN	The Great Lakes Health Effects Research and Information Exchange Network (RIEN) database describes over 800 health effects studies completed or under way in the Great Lakes basin. Contact: SUNY College of Environmental Science and Forestry, 24 Bray Hall, Syracuse, NY 13210, Tel: (315) 470-6720.
RTECS	The Registry of Toxic Effects of Chemical Substances (RTECS) contains toxicity data for over 100,000 chemical substances.

SEDBASE	Full text database that critically analyses the published drug side effect literature on drugs currently in use.
TOXLINE	Covers the adverse effects of chemicals, drugs and physical agents on living systems.

Canadian Directory to Foundations

This directory is published by the Canadian Centre for Philanthropy which operates a resource centre containing this directory and many other sources of information on funding. The address is:

Canadian Centre for Philanthropy
1329 Bay Street
Toronto, ON M5R 2C4
Tel: (416) 515-0764

Environmental Grantmaking Foundations

This publication describes U.S. and Canadian foundations that fund environmental projects. It is published by the:

Environmental Data Resources Institute
P.O. Box 22770
Rochester, New York 14692
Tel: (716) 473-3090
(800) 724-1857
Cost: $91.50 U.S.

The Epi Info computer programs developed by the World Health Organization and the Center for Disease Control in Atlanta provide public-domain software for word processing, and management, organization and analysis of health data. Version 6 of the program, released in June 1994, can produce and use hypertext (active text), and has a configurable pull-down menu, additional statistics and other improvements over previous versions.

A 600-page manual is included on the disks and is available in printed form. Copies of Epi Info and a companion program for geographic mapping (Epi Map) are available from:

USD, inc.
2075A West Park Place
Stone Mountain, GA 30087
U.S.A.
Tel: (404) 469-4098
Fax: (404) 469-0681

There are charges for Epi Info and Epi Map.

Epi Info and Epi Map are available on the worldwide Internet at the following address:

Site: FTP.CDC.GOV
User ID: Anonymous
Directory for Epi Info: /PUB/EPI/EPIINFO
Directory for Epi Map: /PUB/EPI/EPIMAP

The compressed files occupy 3-4 megabytes for each product.